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Monday, 19th June 1882.

THE RIGHT HON. LORD MONCREIFF, President, in the Chair.

The Council having awarded the Keith Prize, for the Biennial Period 1879–81, to Professor Chrystal, for his paper "On the Differential Telephone," published in the Society's *Transactions* for the Session 1879–80, the Chairman presented the prize.

Professor Tait, in explaining the grounds of award, said that Professor Chrystal's paper was one of very high scientific interest and value, and contained much that was wholly original. But, what would be more readily understood by the majority of the Society, it was one which contained the description and theory of a new instrument destined undoubtedly to improve in a marked manner the measurement of electric capacities. Our means of measuring these have been, by this paper, raised from mere "rule of thumb" to real experimental accuracy. And the subject for measurement is one whose scientific and whose practical importance are every day becoming greater.

The Council having awarded the Neill Prize for the Triennial Period 1877–80, to Mr. John Murray, for his paper "On the Structure and Origin of Coral Reefs and Islands," communicated to the Society on April 5, 1880, and printed (in Abstract) in the *Proceedings* for that date, the Chairman presented the prize.

Mr. Buchan, in explaining the grounds of the award, said— The Council has awarded to Mr. John Murray the Neill Prize for the triennial period 1877–80, for his paper on "The Structure and Origin of Coral Reefs and Islands," which was communicated to the Society on April 5, 1880, and thereafter printed, in abstract, in the *Proceedings* of the Society.

One of the most remarkable results of the voyage of H.M.S. "Beagle," which was undertaken forty years ago, was the publication by Mr. Darwin of his book *On the Structure and Distribution of Coral Reefs*, in which he advanced a theory of their mode of formation which was at once universally accepted by scientific men, and may be stated to have been all but universally entertained till the publication of Mr. Murray's paper on Coral Reefs.

He had the good fortune, about the commencement of his scientific career, to serve as naturalist on board the "Challenger" during its voyage of discovery round the world. Among the new facts and ideas we owe to that celebrated expedition, and the skill with which it was conducted, those referring to the amount and distribution of oceanic life from the surface to a depth of about 100 fathoms, and the different chemical processes at work both at great depths and near the surface, must be named as among the more prominent.

The great merit of his paper consists in having brought these new facts and ideas to bear on the structure and origin of coral reefs. He has shown how the foundations for coral reefs have been prepared by the disintegration of volcanic islands and by the building up of submarine volcanoes by the deposition on their summits of sediments composed mainly of dead organisms. He has further shown that the food of the coral consists chiefly of the abundant oceanic life brought ceaselessly to them by the surface drift currents of the tropical regions; and that the extensive solvent action of sea-water, which so completely removes the carbonate of lime-shells at great depths of the ocean, holds no place at the shallow depths which form the habitat of the coral.

Without going further into details, it may here suffice to say that the theory of coral reefs propounded in Mr. Murray's paper renders it unnecessary to the geologist to assume, in explanation of some of the more difficult problems presented to him, the occurrence of great and repeated general subsidences which have formed one of the great difficulties of geology; and that from the general acceptance the theory is receiving from scientific men, particularly from those specialists whose domains in science it touches most nearly, it is already taking the place so long held by the ingenious and fascinating theory of Mr. Darwin.

The following Communications were read:—

1. On Mirage. Part III. By Professor Tait.

2. On a Red Resin from *Dracœna Cinnabarri* (Balf. fil.) Socotra. By J. J. Dobbie, Assistant to the Professor of Chemistry, University of Glasgow; and G. G. Henderson, B.Sc. Communicated by Dr. Bayley Balfour.

3. On Voice-Effort and Rhythm. By the Rev. J. L. Blake. Communicated by Professor Crum Brown.

(*Abstract.*)

In this paper the author enunciates and illustrates the following propositions:—Speech is produced by distinctly separate jets of breath emitted under pressure; each such jet he names a monopressure. A monopressure may be used for the utterance of a single syllable, which may consist of a single vowel, or a vowel preceded or followed, or both, by consonants. In a monopressure the sound is weaker at the beginning and end, and stronger in the middle. The weak beginning, or the weak ending, of a monopressure, or both, may be used for the utterance of an unaccented syllable. There are thus four forms of a monopressure:—monosyllabic; dissyllabic, with the accent on the first; dissyllabic with the accent on the second; trissyllabic, with the accent on the second. These the author marks thus $|$, $\llcorner$, $\lrcorner$, and $\perp$. A large number of examples is given. The following will indicate the use of the marks,—$\overset{|}{\text{act}}$, $\overset{\llcorner}{\text{acting}}$, $\overset{\lrcorner}{\text{react}}$, $\overset{\perp}{\text{reacting}}$. The syllables (when there are more than one) of a monopressure need not, of course, all belong to one word; and many words require more than one monopressure for their utterance. Thus words of three syllables require two monopressures, unless the

accent is on the second. If the accent is on the first, they are of
└ |
the forms └ |; if on the last, of the forms | ┘. Examples—accident,
| ┘
recollect. The monosyllabic pressure in these words marks a secondary accent. A similar analysis is given of the pressures on words of four, five, six, seven, and eight syllables, with varied position of the primary and secondary accents. It is shown that not more than two unaccented syllables can occur together. A sentence may begin with three apparently unaccented syllables—for instance, "in the beginning;" but these words must have two pressures, one effecting the utterance of the words "in the" and the other sufficing for the word "beginning," the notations being └ ┴. The amount of pressure in a monopressure can be varied. The author recognises three degrees corresponding to the accent, the secondary accent, and the accent by position.

The same sentence may be uttered in a great variety of ways, by varying the number and form of the monopressures. Children beginning to speak use a monopressure for each syllable. A proper distribution of the syllables to the monopressures and a proper regulation of the strength of the latter, so as to fit the meaning of each sentence, are essential elements of good speaking and reading. By means of examples from Shakespeare and Milton, the author shows how rhythm in verse depends upon the arrangement of the four forms of monopressure. He believes his theory and the notation founded on it may be successfully applied to instruction in pronunciation and rhythm, to textual criticism of Shakespeare, and to the decision of questions as to accentuation in Hebrew and Greek, and that it may lead to the economy of breath pressure and voice, and to an easy elocution which only an understanding of the mode in which voice is produced can help to perfect.

4. The Effect of Moisture on the Electric Discharge. By A. Macfarlane, M.A., D.Sc., and D. Rintoul, M.A.

(*Preliminary Notice.*)

In his recent lectures on Solar Physics,* Professor Stokes, while expounding his theory of the connection of magnetic disturbances, auroræ, and earth currents, says:—"We might not have tension enough to produce such a discharge (that is, a flash of lightning), the resistance to the passage of electricity from one portion of the air to another, which at any rate would be comparatively dry compared with what we have in warm latitudes, would prevent it by itself alone." Professor Stokes subsequently remarked in a letter to *Nature*:†—"These words, without actually asserting, seem to imply that the resistance to such a discharge through moist air would be less than through dry. My attention has been called by a friend to the fact that it has been found by experiment that moist air insulates as well as dry. I have not met with experiments tending to show whether the resistance to a *disruptive* discharge is the same or not in the two. Be that as it may, it does not affect what follows; for we know, as a fact, that thunderstorms are absent in high latitudes."

To the question here asked we have endeavoured to furnish an answer. The experimental method adopted was the same as that described in our paper on "The Effect of Flame on the Electric Discharge."‡ The spark was taken between two brass discs, each 4 inches in diameter, supported parallel to one another inside a receiver, after the manner described in former papers.§ The drying of the air was effected by first exhausting the moist air out of the receiver, and then allowing the air of the room to pass in slowly through one or more sulphuric acid tubes. In our first trials one drying tube was employed, but in the later trials two. Care was always taken that the air through which the discharge passed was at the atmospheric pressure. To obtain the humidity of the air of the room, the readings of a dry and of a wet bulb thermometer were noted.

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* *Nature*, vol. xxiv. p. 615.

† Vol. xxv. p. 30.

‡ *Proc. R.S.E.*, 6th March 1882, p. 567.

§ *Phil. Mag.*, Dec. 1880.

The following table gives the results of our different trials. The order of procedure is given in column sixth. A number of readings were first taken for the air of the room, then the receiver was exhausted to a pressure of 5 mm. or so, and the air subsequently allowed to enter slowly through the drying tube or tubes. When the state of the air was again changed, it was done by allowing the air to enter without passing through the drying tubes. The number entered in the seventh column is the mean of ten or six readings.

It will be seen that in the case of the great majority of the comparisons, the reading for the undried air is less than for the dried air, and that this is universally true in the case of the first comparison in each series. The diminution of the difference in the case of the subsequent comparisons of a series may be due to the fact, that to obtain undried air a second time, we allowed the air of the room to enter through the already dried passages of the air-pump.

The series observed on 26th May is the one in which the drying was most carefully performed; the conclusions which it supports are those which might be deduced from the other series taken collectively. In the case of this series, the individual observations are as follow:—

DIFFERENCE OF POTENTIAL.

Reading.	First State. Undried.	Second State Dried.	Third State Undried.
1st.	240	258	253
2nd.	242	270	262
3rd.	241	283	258
4th.	248	258	255
5th.	250	257	255
6th.	247	261	250
Mean,	245	265	255

RESULTS OF TRIALS.

Date.	Thermometer.		Pressure of Atmosphere.	Spark-length in Millimetres.	State of the Air.	Mean of Differences of Potential.	Percentage Ratio of Increment to Reading for Undried.
	Dry.	Wet.					
May 12.	16·1	12	...	6	Undried.	367	17
,,	...	...	...	6	Dried.	429	3·4
,,	...	...	...	6	Undried.	415	
May 15.	16	11·8	755 mm.	6	Undried.	400	8·5
,,	...	...	...	6	Dried.	434	
May 18.	16·8	13	755·4	3	Undried.	180	4·4
,,	...	...	...	3	Dried.	188	
,,	18	14	...	3	Undried.	191	4·2
,,	...	...	...	3	Dried.	199	
,,	18·2	14·2	...	5	Dried.	314	3·1
,,	...	...	...	5	Undried.	305	
May 19.	17·7	13·9	755·6	2	Undried.	140	5·0
,,	...	...	...	2	Dried.	147	
,,	...	...	...	4	Dried.	242	11
,,	...	...	...	4	Undried.	218	
,,	18·8	15	...	6	Undried.	365	0
,,	...	...	...	6	Dried.	358	
,,	...	...	...	6	Undried.	353	
May 24.	17·8	14·6	755·4	6	Undried.	348	16
,,	...	...	...	6	Dried.	406	
May 25.	19	15·8	755·9	1	Undried.	89	5·6
,,	...	...	...	1	Dried.	94	
,,	...	...	...	2	Dried.	151	1·4
,,	...	...	...	2	Undried.	149	
,,	...	...	...	3	Undried.	210	0
,,	...	...	...	3	Dried.	210	
,,	...	...	...	4	Dried.	254	−3·1
,,	...	...	...	4	Undried.	262	
May 26.	19	15·6	755·7	4	Undried.	245	8·2
,,	...	...	...	4	Dried.	265	3·9
,,	20·4	16·7	...	4	Undried.	255	

Added 17th November.

The following series of observations was made on the 31st May. The readings for the undried state, with different spark-lengths, were first observed, the air was then dried once for all, and readings taken for the several spark-lengths. This method of comparison has the advantage of saving time in drying the air, but the disadvantage of requiring the distances of the plates to be readjusted. An error in this respect may account for the different result obtained in the comparison at 3 mm. Four readings were taken in each case. Wet bulb thermometer 16·8. Dry bulb thermometer 20·2.

Spark-length in Millimetres.	State of the Air.	Mean of Differences of Potential.	State of the Air.	Mean o Differences of Potential.	Percentage Ratio of Increment to Reading for Undried.
1	Undried.	67	Dried.	80	19·4
2	,,	119	,,	126	5·9
3	,,	168	,,	166	−1·2
4	,,	222	,,	238	7·2
5	,,	280	,,	285	1·8
6	,,	339	,	347	2·4

5. The Heats of Combination of the Metals with the Halogens. By A. P. Laurie and C. I. Burton. Communicated by Professor Crum Brown.

Professor Chrystal, in his article on "Electricity" in the *Encyclopœdia Britannica*, mentions the following formula of Sir William Thomson's, connecting the heats of combination in a voltaic cell with the EMF of the cell.

$$E = Je\theta.$$

(Where E = EMF of the cell; J = Joule's equivalent; e = amount of zinc, dissolved by unit current in unit time; θ = heat of combination of one grm. of the metal in the cell.)

This formula has been tested for the Daniell and other cells.

It occurred to me that it was peculiarly applicable to the cuprous chloride cell and to the iodine cell recently described to the Society, on account of the simplicity of the reactions in both these cells, and that it could in this way be used as a simple method for the determination of the heats of combination of the metals with the halogens, by determining their electromotive forces, as the active elements in one or other of these cells. Mr. Burton and I accordingly set to work to investigate the matter.

In our first experiments we used an iodine cell and a cuprous iodide cell, the cuprous iodide being used in place of cuprous chloride.

The EMF of a cuprous iodide cell depends on the heat of combination of zinc with iodine minus the heat of combination of copper with iodine. The heat of combination of copper with iodine may be found by using copper as the positive metal in the iodine cell. Or we may determine the heat of combination of zinc with iodine directly in the iodine cell. The cuprous iodide cell, however, offers some advantages. The heat of combination of almost any metal with iodine can thus be measured.

The same method is applicable to chlorine and bromine compounds. The results obtained so far have been very satisfactory. Our numbers usually differ a little from the numbers found in calorimeter experiments. This discrepancy is to be expected, as the circumstances under which the combinations take place are so different in the two cases, and as we have not yet attempted any corrections.

The simplicity and rapidity of the method are sufficiently obvious, and it is particularly applicable to cases where only very small quantities of a metal can be obtained, and where the metal, when obtained, is too rare to be wasted in the calorimeter.

We hope to communicate to the Society the account of our experiments at a future meeting.

Monday, 3rd July 1882.

PROFESSOR DOUGLAS MACLAGAN, Vice-President, in the Chair.

The Chairman read the following Notice as to the Government Grant of £4000 for scientific purposes, which has been prepared by Mr. John Murray, one of the Society's representatives on the Committee. He remarked that it is most desirable that this Notice should obtain wide circulation in Scotland, as there have hitherto been very few applications from this country.

"The Council have requested me to make a statement to the Fellows of the Society with respect to Scottish applications for grants from the Government Grant of £4000 for the promotion of scientific research.

"Our Society, it will be remembered, has two representatives on the Committee which has the distribution of these funds. If those Fellows who intend making application for grants from the funds will submit their applications to the Council of this Society before forwarding them to the Government Grant Committee, the Council will be glad to instruct their delegates to support the applications, should these, in the opinion of the Council, be deemed suitable.

"The same remark applies to those persons living in Scotland, and not Fellows of the Society, but who choose to submit their applications for the consideration of the Council previous to their transmission to the Government Grant Committee.

"In all cases it would be well that the delegates of the Society should be informed of the nature of the applications previous to the meeting of the Committee."

The following Communications were read:—

1. On the Kinetic Theory of Gases in relation to Dissociation.

By Professor Tait.

2. On the Change in the Peltier Effect due to Variation in Temperature. By Albert Campbell. Communicated by Dr. Knott.

The series of experiments here described had for their object the measurement of the variation in the Peltier effect due to change of temperature; they were made during the last six weeks. The arrangement which I used in these experiments was suggested by a form of apparatus used in Professor Tait's laboratory; the following is a description of it. A plate of sheet lead (say) is bent into the shape of an arch (Ω-shaped), and to its lower edges are soldered two plates of sheet-iron, to the opposite edges of which are soldered three or four copper wires proceeding to mercury-pools, which can be put into connection with a battery. In the trenches between the iron and lead are inserted the opposite ends of an iron-German silver thermopile of twelve to twenty junctions; these junctions are placed so that their points may nearly touch the junctions of the iron and lead plates, from which they are insulated by a thickness or two of thin paper. The whole is then wrapped tightly in cotton wool and pushed into a tin box, which is rolled round with flannel and placed in a larger tin box containing boiling water, an arrangement which gives a sufficiently uniform temperature in the inner box. The thermopile of iron and German silver wires has two advantages; first, these two metals give, for a given difference of temperature, a greater deflection than any other pair of easily obtainable metals; secondly, the deflection is very nearly proportional to the difference of temperatures.

The following is my method of working: I connect the thermopile with the galvanometer, turn on the battery current for thirty seconds (say), and note the galvanometer deflection at the end of this time; for the next thirty seconds the current is allowed to remain off, and at the end of this period the deflection is again noted; the current is then turned on for thirty seconds in the opposite direction, the deflection taken, the battery left off for another thirty seconds, the deflection again taken, and so on as at the beginning. This cycle of operations is gone through a number of times in order to get an average result.

If the deflections be A, *a*, B, *b*, C, *c*, D, *d*, and so on, then the average of A, *a* – B, *b* – *C*, *c* – D, &c., will be the measure of the Peltier effect.

The following tables give some of my results; the first column gives the direction of the current and the period of time the current was kept on, and the other columns give the corresponding deflections:—

	I. Iron—Lead.		II. Iron—German Silver.		III. Lead—Silver *(Standard).*		IV. Iron—Zinc.	
Min.	20° C.	85° C.	20° C.	93° C.	22°·5 C.	98°·5 C.	23°·8 C.	99° C.
+ ½	- 70	- 82	100		39	62	100	70
off ½	0	- 2	65		15	31	26	30
- ½	70	59	- 35	- 100	- 20	- 36	- 75	- 50
off ½	0	0	- 30	- 60	3	4	- 20	- 3
+ ½	- 72	- 79	70	60	38	61	90	76
——	0	0	44	40	15	28	25	36
- ½	70	69	- 47	- 90	- 30	- 43	- 105	- 43
——		0	- 20	- 55	- 8	- 3	- 27	- 0
+ ½		- 77	70	50	27	64	82	72
——		- 12	51	——	5	27	17	58
- ½		58	- 45	——	- 40	45	- 104	- 26
——		- 12	- 20	+ 70	- 17	- 8	- 28	+ 20
+ ½		- 72	80	- 45	19	57	81	101
			45		- 2	22	18	62
			- 49		- 45	52	- 105	- 22
					- 22	12		
					15	58		
					- 5	19		
					- 46	- 47		

I also tried Pb. brass with a one-cell Bunsen battery; with my galvanometer very sensitive, I failed to get any deflection; I have since found that the brass line lies very near the lead line, so that this result agrees with the diagram.

The following table (V.) gives the ratios of the Peltier effect at the lower temperature to that at the higher temperature for the various pairs of metals—1st, according to these experiments; 2nd, according to Professor Tait's thermo-electric diagram:—

Metals.	Lower Temp.	Higher Temp.	Campbell.	Tait.
Fe-Pb................	20° C.	85° C.	·991	1·02
Fe-Arg....	20°	93°	·86	·803
Pb-Ag (*Standard*)..	22°·5	98°·5	·582	·545
Fe-Zn.................	23°·8	99°	1·43	1·36

It should be remarked that the battery used was not the same for all the pairs of metals; sometimes one Bunsen cell, sometimes three, were used. Hence these experiments give no means of comparing the Peltier effect for different pairs.

3. On the Lowering of the Maximum Density Point of Water by Pressure. By Professor D. H. Marshall, Professor C. Michie Smith, and R. T. Omond, Esq.

At the meeting of 17th April we gave an account of some experiments made at the request of Professor Tait on the lowering of the maximum density point of water by pressure. We called the notice we gave of these experiments at that time preliminary, because we were anxious to perform further experiments to satisfy ourselves thoroughly of the correctness of the important conclusions then arrived at. We desire now to state that we have repeated these experiments with some slight improvements in experimental details, and at different temperatures, and are glad to state to the Society that our further experiments quite bear out the conclusions previously arrived at. The following will suffice to show the nature of any day's experiment. [For description of the apparatus used, &c., see *ante*, p. 626.]

I. The galvanometer is adjusted, and its delicacy, that is the value of its scale-reading for one degree centigrade of difference of temperature of the thermo-electric junctions, tested.

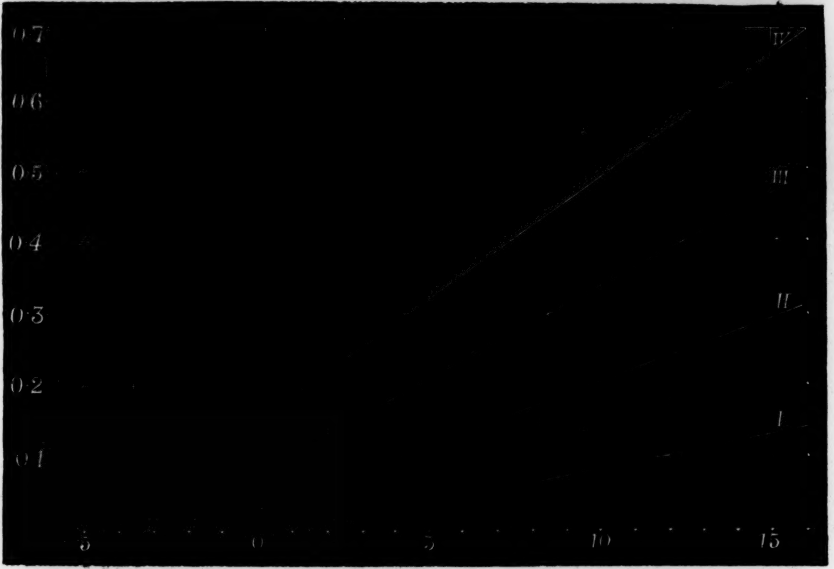
II. A series of experiments are then made, each of the following nature:—The vessel of water containing one thermo-electric junction is subjected to a certain pressure, known and recorded. While under pressure, the junctions are put in connection with the galvanometer, and the deflection noted; we thus get the difference of temperature between the internal and external junctions. The actual temperature of the external junction is simultaneously read on a very delicate and accurate thermometer. Then the pressure is let off, and the heating or cooling of the water, as shown by the junction inside, observed on the galvanometer.

III. After a set of experiments made at pressures varying from 50 to 600 atmospheres, the galvanometer is again tested, and any small change allowed for in calculating out the results obtained.

In many experiments made on water between 0° and 4° cent., with pressures under 1 ton weight per square inch (150 atmospheres), we got a faint indication of cooling when the pressure was applied, but no appreciable change when it was let off. As the question of the change of the maximum density point is only attacked in an indirect manner in these experiments, we did not look for exact quantitative results. Thus, by comparing several days' experiments, we find that in order that water may neither heat nor cool when released from 1½ tons per square inch pressure, it must have a temperature of from 0·2 to 0·5 degrees centigrade. But we do not regard ourselves as justified in stating that the maximum density point for water at this pressure lies within these narrow limits.

The diagram below gives our results in a convenient form. Horizontally we have the initial temperatures of the water under compression in degrees centigrade. Vertically the numbers represent tenths of a degree centigrade, and show the amount of cooling which takes place on release. Line I. is drawn through the various points obtained by letting off 1 ton per square inch pressure (150 atmospheres) at different initial temperatures, and noting the effect produced. Lines II., III., and IV. are similarly drawn for 2, 3, and 4 tons respectively.

From these curves it is evident that in the case of 4 tons pressure, if the temperature of the water experimented on be 15° cent. to begin with, there is on release a cooling effect of about 0°·68; while if the initial temperature be 0° cent., there is still a cooling effect of about 0°·15, thus showing that the maximum density point of water under 4 tons pressure (600 atmospheres) does not lie between 0° and 15° cent., but is driven below the freezing point. Line I., however, crosses the axis at about 1°·5. That is to say, we found that water which, when released from 1 ton pressure (150 atmospheres), cooled about 0°·13 when its temperature was 15°, did not change when its temperature lay between 1° and 2°, and at lower temperatures heated slightly on release.



Some of the discrepancies observed by us on different days may probably be explained by convection currents in the vessel of water, due to the change of the maximum density point under varying pressure, and by changes in the delicacy of the galvanometer. We mentioned in our previous notice how we were disturbed by the constant change in the magnetic field by the passing of carts, &c., on the street. We found that even the motion of the handle of the pump affected the galvanometer, and this was indeed the cause (till it was detected) of our taking double readings in many of our observations.

Some experiments we performed on salt water of the density of sea water, although quite in accordance with the received opinion that salt water has no maximum density point, led us to suspect a maximum density point below zero centigrade. Thus, for 1 ton per square inch pressure, our experiments show that a line drawn as in the fresh water diagram above, would cross the axis at about − 5°, that the corresponding 2 ton line would cross at − 8°·5, the 3 ton line at − 11°, and the 4 ton line at − 13°. Whereas, the corresponding points in the fresh water diagram are + 1°·5, − 1°·5, − 3°, and − 4°·2 respectively. We found also that for equal initial temperatures the heating effect produced by a sudden increase of pressure was greater in salt than in fresh water. As the experiments with salt water were performed at temperatures nearly the same as those with the fresh water, they gave us greater confidence in the correctness of the conclusions we arrived at in the case of the latter.

Note, added July 21, 1882.

A careful consideration of the diagram on page 811 will show that if the rate of change of the maximum density point with pressure be uniform, as is assumed by Professor Tait in his note which follows, then when a line crosses the axis, that is, when there is neither heating nor cooling shown on a sudden release of a certain pressure, the water is at the temperature of the maximum density point for half the pressure that the line represents. The following example will make this clear:—Water at a temperature of 1°·5 cent., when suddenly released from 1 ton on the square inch (150 atmospheres) pressure, is left at the same temperature after the release, as is shown by Line I. in the above diagram. This would at first sight seem to indicate that the maximum density point for water under 1 ton pressure is 1°·5 cent. But if the temperature of the maximum density point is lowered by pressure, it must rise as the pressure falls off, and if the lowering is proportional to the pressure, it will rise uniformly. So, if in the example given above there is no final heating or cooling of the water, it shows that there must be first a cooling and then an equal heating; that is to say, that the maximum density point must be as much below 1°·5 cent. at the beginning of the release of pressure, as it is above it at the end. Now we know that at the end it is 2°·5 above 1°·5 (viz., 4° cent.), therefore it must be 2°·5 below 1°·5 when the pressure begins to fall off. That is to say, the maximum density point for water under 1 ton pressure is $-1°$ cent.

This temperature is only given, of course, as an approximate one. The causes of error enumerated by Professor Tait in his note attached to this paper all affect it, and if the lowering of the maximum density point is not directly proportional to the pressure, it can only be regarded as a very rough approximation.

4. Note on the Preceding Paper. By Professor Tait.

If we assume the lowering of the temperature of maximum density to be proportional to the pressure, which is the simplest and most natural hypothesis, we may write

$$t_o' = t_o - \mathrm{B}p\,,$$

where p is in tons-weight per square inch.

Now Thomson's thermodynamic result is of the form

$$\delta t = \mathrm{A}(t - t_o')\delta p\,.$$

This becomes, with our assumption,

$$\delta t = \mathrm{A}(t - t_o + \mathrm{B}p)\delta p\,.$$

As the left-hand member is always very small, no sensible error will result from integrating on the assumption that t is constant on the right (except when the quantity in brackets is very small, and then the error is of no consequence). Integrating, therefore, on the approximate hypothesis that A and B may be treated as constants, we have for the whole change of temperature produced by a finite pressure p,

$$\Delta t = \mathrm{A}(t - t_o)p + \tfrac{1}{2}\mathrm{AB}p^2\,.$$

I have found that all the four lines in the diagram given in the paper above can be represented, with a fair approach to accuracy, by the formula

$$y = 0{\cdot}0095(t-4)p + 0{\cdot}017p^2\,,$$

where p has the values 1, 2, 3, 4, respectively. Hence, comparing with the theoretical formula, we have the values

$$\mathrm{A} = 0{\cdot}0095\,,\quad \mathrm{B} = 3^\circ{\cdot}6\ \mathrm{C}\,.$$

B expresses the lowering of the maximum density point for each ton-weight of pressure per square inch.

It seems, however, that all the observations give considerably too small a change of temperature; for the part due to the first power of the pressure is from 30 to 40 per cent. less than that assigned by Thomson's formula and his numerical data. One obvious cause of this is the small quantity of water in the compression apparatus, compared with the large mass of metal in contact with it. This would tend to diminish all the results, whether heating or cooling; and the more so the more deliberately the experiments were performed. Another cause is the heating (by compression) of the *external* mercury in the pressure gauge. Thus the pressures are always overestimated; the more so the more rapidly the experiments are conducted. A third cause, which may also have some effect, is the time required by the thermo-electric junction to assume the exact temperature of the surrounding liquid.

Be this, however, as it may, the following table shows the nature of the agreement between the results of my original experiments (*ante*, p. 218) and the data derived from the present investigations. The gauge and the compression apparatus were the same as in my experiments of last year; the galvanometer, the thermo-electric junctions, and the observers were all different. The column MSO gives the whole heating or cooling effect at 15°·5 C., calculated for different pressures from the results of the investigation by Professor Marshall and his coadjutors. The column T contains the results of my direct experiments at that temperature.

p (tons)	MSO	T	Thomson.
1	0·131 C.	0·139 C.	0·177 C.
2	0·294	0·311	0·355
3	0·465	0·516	0·533
4	0·665	0·750	0·711

It will be noticed that there is, again, a fair agreement; though the results are, as a rule, lower than those calculated from Thomson's formula. My own agree most nearly with Thomson's formula, probably because they were very rapidly conducted. As they stand, they give about 3° C. for the effect of 1 ton on the maximum density point. It is to be observed that if we could get the requisite corrections for conduction, and for compression of mercury, their introduction would increase (as in fact is necessary) the constant A above, but would have comparatively little effect on the value of B, which is the quantity really sought.

5. Vocalisation and Articulation. By the Rev. J. L. Blake. Communicated by Dr. Crum Brown.

(*Abstract.*)

In this paper the author discusses the mechanism of speech, and the character of the vowels and consonants which occur in the English language. He points out the importance of attending to the proper division of words into syllables, and of clearly articulating consonants. He shows how his theory of monopressures facilitates the correct reading of poetry.

BUSINESS.

Mr. Andrew Jameson and Mr. J. A. Wenley were balloted for and declared duly elected Fellows of the Society.

Monday, 17*th July* 1882.

PROFESSOR BALFOUR, Vice-President, in the Chair.

The following Communications were read:—

1. On the Order of Succession of Rocks in the North-West Highlands. By Professor Heddle.

2. On the Rotation of the Plane of Polarization by Quartz, and its relation to Wave-Length. By W. Peddie. Communicated by Professor Tait.

The angular rotation of the plane of polarization of light-rays in their passage through quartz is a function of the wave-length, and is roughly represented by the formula

$$\rho = \frac{A}{\lambda^2},$$

where A is a constant depending on the quartz. This formula is only approximate, however, and one object of the experiments described below was to ascertain how closely the rotation might be represented by three terms of the equation

$$\rho = \frac{A}{\lambda^2} + \frac{B}{\lambda^4} + \frac{C}{\lambda^6} + \dots$$

Another object was to test the amount of accuracy attainable by the exceedingly simple and direct method employed; and a third was to find how nearly the constants in the assumed formula agree with one another in different specimens of quartz.

A quartz plate 8·9 mm. in thickness was first used with ordinary Nicol's prisms, as polariser and analyser. The quartz plate was fixed immediately in front of the analysing prism. A beam of sunlight, having passed through the polariser and the quartz, proceeded through the upper half of the analyser. Another beam was reflected through the under half by a mirror placed between the polariser and the quartz. Both beams being then passed through a spectroscope, two spectra were obtained in juxtaposition, the Fraunhofer lines in the one exactly corresponding to those in the other. The upper one exhibited in addition the usual dark band caused by the rotatory action of the quartz upon the plane polarised ray.

The analyser being now moved round until the centre of the dark band coincided with a Fraunhofer line in the under spectrum, the angle recorded gave the total rotation for that ray, minus some multiple of π. That position of the analyser, for which all rays were extinguished when the quartz was withdrawn, was of course taken as the standard position from which all angular deviations were reckoned. The following results were obtained from observations with the rays D, E, b, F :—

Ray.	Scale Readings.										Mean.	Corresp. Rotation.	Total Rotation.
D	85° 20′	85° 40′	85° 12′	85° 36′	85° 30′	85° 42′	85° 12′	85° 20′	85° 28′	85° 12′	85° 25′	14° 35′	194° 35′
E	35° 52′	35° 52′	35° 8′	35° 48′	34° 52′	35° 18′	35° 16′	35° 14′	35° 32′		35° 26′	64° 34′	244° 34′
b	26° 0′	26° 56′	26° 20′	26° 30′	25° 16′	25° 56′	25° 54′	25° 16′	25° 10′		25° 55′	74° 5′	254° 5′
F	10° 32′	10° 44′	10° 30′	10° 36′	10° 52′	10° 24′					10° 36′	110° 36′	290° 36′

The angles recorded under the heading "Corresponding Rotation" are explained by the fact that the scale-reading 100° is taken as the standard of reckoning. The multiple of π to be added is easily obtained from the approximate formula $\frac{\rho_1}{\rho_2} = \frac{\lambda_2^2}{\lambda_1^2}$.

Hence, to the sixth power of the wave-length (rotations being expressed in minutes, and wave-lengths in fractions of an inch),

$$\rho(\mathrm{D}) = 11675 = \frac{A}{5381} + \frac{B}{(5381)^2} + \frac{C}{(5381)^3}.$$

$$\rho(\mathrm{E}) = 14674 = \frac{A}{4303} + \frac{B}{(4303)^2} + \frac{C}{(4303)^3}.$$

$$\rho(\mathrm{F}) = 17436 = \frac{A}{3662} + \frac{B}{(3662)^2} + \frac{C}{(3662)^3}.$$

These equations give

$$A = 6661(10)^4, \; B = -4233(10)^7, \; C = 1180(10)^{11}.$$

Applying the formula

$$\rho = \frac{6661(10)^4}{\lambda^2} - \frac{4233(10)^7}{\lambda^4} + \frac{1180(10)^{11}}{\lambda^6}$$

to calculate the rotation for the ray *b*, where $\lambda = 0{\cdot}00020367$, we get

$$\rho = 16069{\cdot}6 - 2463{\cdot}3 + 1656{\cdot}9 = 15263.$$

The value obtained by direct observation, as given in the table above, is 15245.

With another specimen of quartz 70 mm. in length, the following results were got:—

Ray.	Scale Reading.	Mean.	Angle. Corresp.	Total Rotation
D	21°, 23°, 22½°, 21°, 21½°, 21°, 21°, 22°, 22°, 22°	22°	78°	1518°
E	128°, 128½°, 128°, 129°, 128°, 128°, 128½	128°	128°	1928°
b	72°, 73°, 73°, 72°, 72°	72½°	27½°	2007½°
F	129°, 129°, 131°, 129°, 129°, 129°, 130°, 130°, 129°, 129°	129°	151°	2311°

To find the multiple of π to be added to the measured rotation for the ray D, let $y =$ the ratio of the length of the long quartz to the length of the short, $a_1 =$ the rotation for D in the short quartz, $a_1' =$ the rotation for D in the long quartz above the nearest dark band in the less refrangible part of the spectrum, then,

$$a_1 y = n\pi + a_1'.$$

Similarly for the ray E, $a_2 y = n\pi + a_2'$, where a_2' is equal to $2\pi + 128°$. Combining the equations for the different rays,

$$y\Sigma a^2 = n\pi\Sigma a + \Sigma aa'.$$

This equation gives $n = 8$. Hence

$$\rho(\text{D}) = 91080 = \frac{\text{A}}{\lambda_{\text{D}}^2} + \frac{\text{B}}{\lambda_{\text{D}}^4} + \frac{\text{C}}{\lambda_{\text{D}}^6},$$

$$\rho(\text{E}) = 115680 = \frac{\text{A}}{\lambda_{\text{E}}^2} + \frac{\text{B}}{\lambda_{\text{E}}^4} + \frac{\text{C}}{\lambda_{\text{E}}^6},$$

$$\rho(\text{F}) = 138660 = \frac{\text{A}}{\lambda_{\text{F}}^2} + \frac{\text{B}}{\lambda_{\text{F}}^4} + \frac{\text{C}}{\lambda_{\text{F}}^6}.$$

The values obtained for the constants are $\text{A} = 5289(10)^5$, $\text{B} = -4896(10)^8$, $\text{C} = 1509(10)^{12}$.

Using these values, $\rho(b) = 120200'$. The observed rotation is, $120450'$. Reducing the constants to their value per mm., we get, for the short quartz,

$$\text{A} = 7485(10)^3,\ \text{B} = -4756(10)^6,\ \text{C} = 1326(10)^{10};$$

and for the long quartz,

$$\text{A} = 7557(10)^3,\ \text{B} = -6995(10)^6,\ \text{C} = 2156(10)^{10}.$$

3. On the Condition of Ammonium Salts when dissolved in Water. By W. W. J. Nicol, M.A., B.Sc. Part I.

When a salt, such as sodium chloride, which crystallises at ordinary temperatures without water of crystallisation, is dissolved in water, contraction takes place; that is, the specific gravity of the solution is greater than that calculated for a solution of that strength from the specific gravity of the salt in the solid state and that of water, by the formula—

$$\frac{100}{\frac{p}{d}+\frac{P}{D}} = \text{theoretical specific gravity of the solution.}$$

Where—

p = the percentage of salt in the solution.
d = the specific gravity of the solid salt.
P = the percentage of water.
D = the specific gravity of water at the temperature of observation.

The amount of this contraction varies greatly, being as much as 31·2 per cent. in the case of potassium sulphate, and only 2·5 per cent. in the case of potassium ferricyanide, when the salt dissolves in a nearly saturated solution, the volume of the solid salt being taken as 100.*

The above is the general rule, but it has been long known that ammonium chloride, when dissolved in water, expands instead of apparently contracting, consequently the specific gravity of its aqueous solution is always less than the theoretical. The amount of this expansion varies with the strength of the solution. Sorby (*loc. cit.*) states that when the solution contains 3 per cent. of the salt the expansion is 3·4 per cent., while near the point of saturation it is 15·8 per cent.

This apparent expansion of ammonium chloride has been observed by various experimenters, who all agree that it is the only known exception to the general rule. Table I. gives the numbers obtained by the more important of these, the theoretical specific gravity of the solution, calculated from the number 1·53 = sp. gr. solid ammonium chloride, being given in the right-hand column.

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* Sorby, *Proc. Roy. Soc.*, xii. 544.

TABLE I.

Observer.	Per cent.	Observed sp. gr.	Theor. sp. gr.
Hassenfratz,[*]	19·3	1·0693	1·0718
Michel et Krafft,[†]	24·7	1·0752	1·0935
Schiff,[‡]	26·9	1·0767	1·1028
Gerlach,[§]	26·3	1·0766	1·1002

Schiff (*loc. cit.*) says, that the fact already observed by Michel and Krafft—that ammonium chloride expands on dissolving in water is confirmed by his experiments, but is unable to offer any explanation of the cause of it. While Gerlach, writing in 1859, and again in 1862,[||] after a long series of most careful experiments, extending over numerous salt solutions of various strengths, and with complete knowledge of the work done on the subject by Kremers, Schiff, Karsten, and others, has no hesitation in stating, that in the act of solution contraction takes place in the case of all anhydrous salts, with the single exception of ammonium chloride. Finally, Sorby (*loc. cit.*) found that, in the case of salts which produce contraction on solution in water, the effect of pressure is to increase the solubility, while with ammonium chloride the reverse is the case; pressure, as was to be expected, diminishing the solubility.

Not only is the specific gravity of solutions of Ammonium chloride abnormal, as shown above, but some of the other properties of the solution also show a variation from those to be expected from a consideration of the properties of solutions of potassium and sodium chlorides. For example, Quincke[¶] has determined the cohesion or surface tension of solutions of ten chlorides, including ammonium chloride, by means of the method with capillary tubes and that with air bubbles. On comparing the results of experiment with the numbers calculated,* he finds that there is satisfactory agreement except in the case of 2KCl, $2NH_4Cl$, and $\frac{1}{3}(Fe_2Cl_6)$. A small amount of free hydrochloric acid would account for these variations; and he admits its probable presence in the case of the ferric chloride solution, and believes that the ammonium chloride solution really contains free ammonia and hydrochloric acid. He cannot account for the irregularity in the case of potassium chloride, but it must be noted that it only makes its appearance when the solution experimented with is concentrated, and, in any case, the irregularity is small compared with that found for ammonium chloride solutions.

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[*] *Annales de Chimie*, xxviii. 298.

[†] *Ann. de Chim. et Phys.* [3], xli. 471.

[‡] *Annalen der Chemie*, cix. 330.

[§] *Spec. Gen. der Salzlösungen. Freiberg*, 1859, p. 11.

[||] *Zeitschrift für Analyt. Chem.*, viii. 271.

[¶] Pogg., *Annalen*, clx. p. 560.

The coefficient of absorption for carbon dioxide is also abnormal in the case of ammonium chloride solution. Mackenzie† has determined it for solutions of various strengths of the six chlorides, KCl, NaCl, NH_4Cl, $BaCl_2$, $SrCl_2$, and $CaCl_2$. The result of his experiments is, that whereas, in the case of strontium chloride, the coefficient of absorption lies between those of barium and calcium chlorides, as is the case with the molecular weights, that of ammonium chloride solution exceeds greatly those of potassium and sodium chlorides. I may note, in passing, a mistake that Mackenzie has made in his statement of results. He says (*loc. cit.*): *Für verschiedene Salzlösungen ist der Einfluss des Salzes verschieden, und zwar liegt die absorption beim Chlorkalium, wie sein Moleculargewicht zwischen der beim Chlornatrium und Chlorammonium, u. s. w.*" The absorption does really occupy that position, but not the molecular weight.

Further, the results obtained by Kittler,‡ in his experiments on the electromotive force of an element composed of two solutions and *one* metal point apparently to a similar irregularity in the behaviour of a solution of ammonium chloride, when compared with that of solutions of potassium and sodium chlorides; for when the element

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* By the formulæ—

$$(1)\ (a) = 7\cdot35\ \text{mm.} + \cdot1683\,\eta.$$

$$(2)\ a = 8\cdot30\ \text{mm.} + \cdot1870\,\eta.$$

(1) Tube method; (2) air-bubble method; and η the number of equivalents of salt in 100 equivalents of water.

† Wiedemann's *Annalen*, i. 451.

‡ *Ibid.*, xv. 391, 410.

consists of copper, in a solution of copper sulphate and a solution of one of the three chlorides, KCl, NaCl, NH_4Cl, the order is NH_4Cl, KCl, NaCl; but when the element consists of copper in dilute sulphuric acid and a solution of one of these three chlorides, the position is regular. But, owing to Kittler's adherence to the old plan of regarding salt solutions from the percentage point of view, and his comparing in many cases only the concentrated solutions, it is impossible to state definitely that the above is true.

In the course of some experiments on the specific gravity of saline solutions, my attention was drawn to the divergence from the general rule in the case of ammonium chloride, and I made a series of experiments with the view of determining the cause of it. A portion of these form the contents of this paper.

In the first instance, determinations were made of the specific gravity of aqueous solutions of various strengths of the six salts formed by the union of potassium and sodium, with chlorine, bromine and iodine respectively. The mode of experiment was briefly as follows:—All the specific gravities were taken at 20° C. in a constant temperature bath (a modification of Dupré's) and referred to water at 20° as unity. Sprengel tubes were employed; these after filling were allowed to remain in the bath for ten minutes: after weighing, some of the liquid was poured into a weighed platinum dish, and the percentage of salt determined by evaporation. Three solutions of each salt were prepared, containing approximately 20, 15, and 10 per cent., and these were completely freed from air by boiling and allowing to cool *in vacuo*. In the case of the solid ammonium salts mentioned later, the specific gravity after crystallisation from alcohol, or a mixture of alcohol and water, was taken in paraffin by means of a special form of bottle; the error in experiment affecting the fourth decimal place only slightly.

My determinations correspond very closely with those of Gerlach, made at 15° by the hydrostatic method and corrected.

Table II. contains the results of these preliminary experiments compared with the specific gravity calculated from the most trustworthy determinations of the specific gravity of the solid salt.

TABLE II.

A.	B.	C.	D.	E.
NaCl	20·95	1·15711	1·12322	·03389
2·011	14·44	1·10664	1·08108	·02556
	7·4	1·05339	1·03912	·01427
KCl	19·5	1·13225	1·1067	·02555
1·977	14·93	1·09954	1·0797	·01984
	7·44	1·04914	1·0382	·01094
NaBr	...	1·14714	1·	...
3·014	14·92	1·12473	1·1107	·01403
	11·57	1·09567	1·0838	·01187
KBr	22·04	1·17968	1·1604	·01928
2·681	14·37	1·11317	1·0990	·01417
	8·96	1·06702	1·0596	·00742
NaI	27·5	1·2649	1·2427	·0222
3·45	18·54	1·16626	1·1517	·01456
	12·75	1·11138	1·0996	·01178
KI	23·09	1·19977	1·1840	·01577
3·059	16·00	1·12929	1·1207	·00859
	7·81	1·06127	1·0555	·00577

A = name of salt and specific gravity in the solid state.
B = percentage of salt in solution of specific gravity in C.
C = observed specific gravity of solution.
D = theoretical specific gravity.
E = C – D.

The following points are to be noted :—

1. That in each case the observed specific gravity is greater than the calculated, showing that contraction has taken place ;

2. That the difference C – D in E increases as the percentage of salt increases ; but,

3. That the first portions of salt added produce a relatively greater contraction than the subsequent portions.

Nothing more can be learned from the table in the above form. Experimenters are only just beginning to realise the fact that salt solutions which contain the same percentage of different salts are *not* comparable. Before we can justly expect to be able to throw light on the subject of solution, we must be certain that the solutions which we compare together are *really* comparable. Kremers,* in the course of his numerous experiments on solution, and his deductions from them, compared solutions which contained, as he expressed it, 10, 20, 30 molecules of the salt (*Salzatome*) to the 100 unit weights or unit volumes of water (*Gewichtseinheiten oder Volumeinheiten Wasser*): these numbers, as a reference to his papers will show, are too great, but for all that his solutions were to a certain extent comparable. The source of error which Kremers did not perceive, which indeed so far as I know has not hitherto been recognised, is the mutual attraction of the salt molecules for one another. If we wish to observe the results produced solely by the mutual action of the salt and the water, we must take care that our solutions are sufficiently dilute. As the solution becomes more concentrated, the observed specific gravity depends not only on the attraction of the salt for the water, but also on that of the salt molecules for one another.

With a view to testing the correctness of the above, I plotted the results given in Table II. cols. C. and D. The ordinates representing the specific gravity and the abscissæ the percentages; I thus obtained for each salt two curves approaching straight lines. Both turned upwards, but that expressing the observed specific gravity turned less than the other. The curvature in either case was so slight that it was impossible to draw with any approach to accuracy curves joining the various points; these were therefore joined by straight lines; from these lines the specific gravity for any percentage can be found with moderate exactness; but the difference between the observed and calculated specific gravities can be found with much greater accuracy, as the error affects both lines to very nearly the same extent. By the help of these lines, the actual and theoretical specific gravities were found for solutions containing 1, 2, 4, 6, and even 8 molecules of salt to 100 molecules of water. The differences between these are given in Table III.

* Pogg., *Annalen*, vols. xcii., xcv., cxvi., xcviii., &c.

TABLE III.

100M. H_2O	NaCl	KCl	NaBr	KBr	NaI	KI
1. m. salt.	·0061	·0057	·0059	·0053	·0054	·0065
2. ,,	·0117	·0110	·0102	·0109	·0120	
4. ,,	·0209	·0191	...	·0183	·0200	
6. ,,	·0280	·0261				
8. ,,	·0338	·0288				

These numbers, though not complete, show clearly that the amount of contraction (expressed by the difference between the actual and theoretical specific gravity), produced by dissolving any one of these six salts, in the proportion of one molecule to 100 molecules of water, is a number lying between ·005 and ·006. In the case of two molecules between ·01 and ·012, and that the amount of contraction produced by the addition of each successive molecule, is a steadily diminishing quantity. These points may help to explain the abnormal specific gravity of ammonium chloride solution.

Knowing that solutions of ammonium salts, *e.g.*, chloride, nitrate, and sulphate, became acid on boiling, it struck me that the explanation was to be found in a partial dissociation on solution in water. In order to ascertain whether the dissociation already observed at 100° was due to heat, or whether it actually existed at ordinary temperatures, pure dry air was drawn for three days through a solution of ammonium chloride rendered alkaline with ammonia. At the end of that time the solution was distinctly acid; but as this might be due to the formation of nitrous acid in small quantity, an alkaline solution of ammonium chloride was placed *in vacuo* over sulphuric acid, in less than twenty-four hours it was acid.

The next point to be determined was, whether this abnormal specific gravity was common to all ammonium salts, if so, then the explanation by dissociation would be confirmed. I tried solutions of ammonium, bromide, nitrate, iodide, and sulphate. The specific gravity of the two former was abnormal, that of the two last normal.

Table IV. gives the results of experiments with the solutions of various strengths of the three salts, chloride, bromide, and iodide. It shows that in the case of the first two salts, solution is attended by increase of volume, but that when the last is dissolved contraction takes place as mentioned above.

TABLE IV.

A.	B.	C.	D.	E.
NH_4Cl 1·53	20·68 14·84 8·64	1·06003 1·04408 1·02603	1·07515 1·05219 1·02872	+ ·01512 + ·00811 + ·00269
NH_4Br 2·379	21·28 15·31 10·81	1·12976 1·09048 1·06265	1·1408 1·0973 1·0669	+ ·01104 + ·00692 + ·00435
NH_4I 2·464	18·58 10·92 6·71	1·12631 1·07118 1·0394	1·1241 1·0694 1·0381	– ·00221 – ·00178 – ·00130

The arrangement is the same as in Table II.

The question naturally arises, Why, if ammonium chloride and bromide dissociate to some extent on solution, does ammonium iodide remain intact, as these results seem to show? There is good reason to suppose that dissociation really takes place in this case also, for when these results are treated in the same way as those in Table II., it is found that when one molecule of ammonium iodide is dissolved in 100 molecules of water, the amount of contraction is ·0015. Now from Table III. the amount of contraction in the case of a solution of that strength of one of the six salts there given is ·005 – ·006. Unless dissociation has taken place, I fail to see why ammonium iodide should not give the same amount of contraction.

While searching in Berthelot's *Chimie Mechanique* for some data that might explain this smaller amount of dissociation in the ase of ammonium iodide, I found that the result of Berthelot's experiments on the thermal effect of diluting solutions of the sulphates, chlorides, and nitrates of potassium, sodium, and ammonium is, that we may conclude that these salts are not decomposed by water at the ordinary temperature, to an appreciable extent. But he adds, that we must not lay too much stress on this conclusion; for if the decomposition of ammonium salts of strong acids is not to be detected by the thermometer, it is in consequence of its minuteness—for it really exists, and can be made evident by other proofs.

I hope soon to be able to bring forward other and more complete proofs of dissociation in the above salts, and also to extend my experiments to solutions of other ammonium salts.

4. On a Solar Calorimeter, and some Observations made with it in Upper Egypt. By Mr. J. Y. Buchanan.

(*Abstract.*)

The instrument consists of a Liebig's condenser mounted equatorially, so as to follow the sun by one motion. Projecting from the upper part of it, and enclosing the steam tube, is the boiler, which is a tube of half an inch diameter, where it receives the sun's rays, and widens out to 1 inch diameter in the steam space. This steam space or dome is formed by an inverted test tube, so that the operation can be easily watched. The tube is surrounded by a concave reflector made up of three conical surfaces of silvered copper. The diameter of the outer edge of the reflector is 13·5 inches, and its effective surface is almost exactly 1 square foot. The length of tube on which the rays were concentrated was 2 inches, and as its diameter was half an inch, its surface was 3·14 inches, therefore the thermal magnifying power of the combination was 46. These proportions were chosen in some doubt as to their suitability, but their choice was justified by the result. The amount of water actually in the focal portion of the boiler at any moment was 5 cubic centimetres; as the steam passed down through a central tube, and was condensed by the water rising outside of it to supply the place of what was evaporated in the boiler, the supply or feed to the boiler was effected practically at the temperature of ebullition. When, therefore, the instrument had been working for a few minutes, the whole of the effective radiant heat thrown upon the boiler was utilised in transforming water at 212° F. into steam of the same temperature. As the heat given out in the condensatio of the steam was entirely absorbed by the water going to supply the boiler, and as this heat was sufficient to raise at least eight times the weight of water from the atmospheric temperature to that of ebullition, it will be seen that we are justified in assuming that the solar heat which penetrated the walls of the boiler was wholly utilised in making steam, and further, that loss by radiation was reduced to a minimum.

Immediately on presenting the mirror to the sun ebullition commenced, and it was kept going all the forenoon and the greater part of the afternoon, the position of the reflector being continually adjusted by hand. The distillate was collected in a graduated tube, and the time taken as every portion of 5 cc. was collected. The locality for experiment was that chosen by the eclipse observers,—on the banks of the Nile, close to the Egyptian town of Sohag, in latitude 26° 30′ N. The instrument was very freely exposed to the sky, and was directly shone on by the sun from sunrise till 5 P.M., when it was obscured by a wood. As originally constructed the steam space was of metal, and was much too small, and, consequently, the results obtained in the first few days were vitiated by priming. When this had been thoroughly ascertained, the metal covering was removed and replaced by an inverted test tube, fitted tight with cork packing, the internal steam tube was also prolonged, so as to be well clear of the boiling water surface. The effect of this alteration was, by increasing the volume of the steam space, to eliminate altogether the danger of priming, and, by substituting glass for metal, to enable the operation to be constantly watched. The results obtained before this alteration have been rejected; those made on the 16th, 17th, and 18th May 1882, were subsequent to it, and were quite satisfactory. The results of these observations are condensed in the following table, which gives the amount of water distilled in an hour at different times:—

Time.		Grammes Water Distilled.		
From	To	16th.	17th.	18th.
9	10	...	...	78·1
10	11	58·8	70·25	82·4
11	12	69·5	69·7	82·8
2	3	73·2	65·5	71·6
3	4	...	57·9	64·8

Taking the average performance on the 16th and 17th, which were comparatively cool, we find that 70 grammes, or 0·1542 lb. of water was distilled per hour, and on the 18th, a comparatively hot day, the amount was 81 grammes, or 0·1784 lb. per hour.

Setting aside cloud, the chief perturbing agent is wind. During the three days we were fortunate in having considerable varieties of weather. On the 16th, with a calm afternoon, the mean rate between two and three o'clock was 1·221, and on the 17th, when it was breezy, it was 1·087, or about 10 per cent. less. The breezes which occur on the Nile are cool from the north, and are variable in strength. On the three days mentioned the force was never greater than from 2 to 3, and what there was was always more or less gusty. We have seen that the mean rate between 2 and 3 P.M. on the 16th was 1·221, and the temperature of the air at 2 P.M. was 95° F.; while on the 18th the rate was 1·204, with a temperature of 105° at 2 P.M. On the latter day there was a fresh breeze in the afternoon, while on the former it was calm. If we consider that the lowering of the rate was wholly due to the wind; it appears that air of 105° F. in moderate motion cooled as much as stagnant air of 95° F. It is, however, impossible to be sure that some of the lowering may not be due to alteration in the absorptive power of the air.

The air was always excessively dry. At 2 P.M. the dry and wet bulb thermometers registered, on the 16th, 95° and 62·5°; on the 17th, 94° and 66·2°; and on the 18th, 105° and 68° F. Therefore the difference between the wet and dry bulbs ranged between

30° and 40° F. As an instance of the diurnal range of temperature, it may be mentioned that on the 18th, when at 2 P.M. the temperature was 105° F., just before sunrise it was only 59° F. On this day, therefore, we had an extreme range of temperature of 46° F., and a difference of 40° F. between the dry and wet bulbs themselves in the afternoon. The island of Teneriffe lies in very nearly the same latitude as Sohag; but in order to find a similar climate, it is necessary to ascend at least 6000 feet, and pass through the mass of clouds which always encircle the peak between the heights of 3000 and 5000 feet above the sea. The climate on the Nile in Upper Egypt is thus very peculiar. Looking to the height of the barometer and the day temperature, it is that of a tropical place at or near the level of the sea; looking to the range of temperature and the dryness of the air, it is quite Alpine.

On the morning of the 17th May the sun was totally eclipsed at 8.34 A.M.; at 8.51 the apparatus was exposed to the sun, but no boiling took place; at 8.58 the water began to "sing"; at 9.1 it boiled; at 9.3 it was boiling briskly, but it was not till 9.17 that the first drop of distillate fell into the receiver; by 9.19½ 1 cubic centimetre had passed, and between 9.21 and 9.29½ 5 c.c. passed.

The water did not begin to sing until 50 per cent. of the surface of the sun had been uncovered, a fact which supports the belief that there is a very great absorption of heat rays by the sun's atmosphere near the limbs. During totality the stars shone out brightly, and a comet appeared about a degree distant from the sun. The darkness was not so great but that I could read a rather closely graduated thermometer without difficulty. The fall of temperature during totality was only 1° F., and there was no wind or other atmospheric disturbance.

5. On the Heats of Combination of the Metals with the Halogens. By A. P. Laurie, B.Sc., and C. I. Burton.

At the last meeting of the Society a paper was communicated by us, describing a new method for determining the heats of combination of the metals with the halogens. The following paper is an account of our preliminary experiments mentioned in the former paper. As these experiments were all made with modifications of the "iodine cell," or of the "cuprous iodide cell," we shall begin with a brief description of these two cells.

The iodine cell consists of a carbon rod and a zinc rod immersed in a solution of iodine in iodide of zinc. The cuprous iodide cell consists of a zinc plate and a copper plate immersed in a solution of iodide of zinc, the copper plate being covered with a paste of cuprous iodide, and then wrapped in parchment paper.

The E.M.Fs. of the cells were measured on a Thomson Quadrant Electrometer, the deflection corresponding to 1 volt, being found by measuring the deflection given by a Daniell cell. The Daniell cell was assumed to have an E.M.F. of 1·12 volts. This is not a strictly accurate assumption, but was sufficient for these preliminary experiments. The deflection given by the Daniell cell was measured at the beginning and end of each series of experiments. The zero of the instrument was usually noted after each deflection.

The formula used has been already mentioned. It is

$$\theta = \frac{E}{Je}, \text{ or } \theta = \frac{E}{4{\cdot}2 \times 10^7 \times e} \text{ (in C.G.S. units) :}$$

e is equal to ·003411 grm. for zinc.

On connecting an iodine cell as above described with the electrometer, zinc as the active metal gave a deflection of sixty divisions on the electrometer scale. (The deflection given by a Daniell cell was 52 divisions.)

Copper, as the positive metal, gave no deflection. This was due to the coating of iodide formed on it by the iodine solution. It seems under these circumstances to be in a similar state to negative iron.

We then constructed an iodine cell in the following manner:—

In the centre of a glass vessel containing a solution of an iodide is placed a porous pot, containing the iodine solution and the carbon rod. Closely surrounding the porous pot is a cylinder of perforated zinc with which the iodine combines as fast as it diffuses through the porous pot. In this way the iodide solution in the outer vessel is quite free from iodine.

Experiments with this cell give as an average of five experiments—

Deflection with zinc, 63, in terms of the electrometer scale. As already mentioned, the E.M.F. of zinc in the ordinary iodine cell is about 60.

The difference 3 is due to an E.M.F set up between the iodine solution and the iodide of zinc solution.

The deflection with copper is 33.

Some experiments were then made with a cuprous iodide cell constructed in the manner already described. The following table contains the results :—

Name of Metal.	E.M.F. in Iodine Cell.	Calculated E.M.F. in Cuprous Iodide Cell.	Found E.M.F. in Cuprous Iodide Cell.
Zinc, ...	60·5	30	32
Copper, ...	30·5	0	0
Silver, ...	29	−1·5	0
Lead, ...	39	8·5	10
Tin, ...	29	...	...
Iron, ...	31	·5	0

The second column of figures is found on the assumption that the E.M.F. of a metal in the cuprous iodide cell is its E.M.F. in the iodine cell, *minus* the E.M.F. of copper in the iodine cell.

Three has been subtracted from the numbers in the first column. The reason for doing this has been already explained. Taking 61·5 as the E.M.F. of zinc, which is the mean value, its heat of combination with iodine as calculated from the above formula is 924.

The number given by Naumann for the heat of combination of zinc with iodine in presence of water is 929.

Nearly all our other numbers agree approximately with those given in Naumann's *Thermochemie.*

The numbers, taken from Naumann's table, are the heats of combination of one gramme of the metals in presence of water. It will be seen that the value given for iron by Naumann does not show any agreement with our value. This is also the case with the chlorine and bromine compounds of iron.

Reaction.	E.M.F. of Metal.	Heats of Combination, calculated from E.M.F.	Heats of Combination, from Naumann's Table.*
$Zn+I_2=ZnI_2$ . .	1·324 volts.	924 heat units.	929 heat units.
$Cu_2+I_2=Cu_2I_2$ . .	·657 ,,	235 ,,	256 ,,
$Ag_2+I_2=Ag_2I_2$ . .	·624 ,,	131 ,,	127 ,,
$Pb+I_2=PbI_2$ . .	·861 ,,	189 ,,	191 ,,
$Fe+I_2=FeI_2$ . . .	·667 ,,	523 ,,	851 ,,

In order to test the effect of temperature on the E.M.F. of the cell, the E.M.F. of zinc in an iodine cell was measured when the cell was at 11° C., and when it was at 27° C. The E.M.F. in both cases was the same.

The deflection given by silver wire and silver electrolytically deposited from pure nitrate of silver is the same.

Iron wire with a blue tarnish on it gives a considerably less deflection than clean iron.

The E.M.F. given by alloys seemed to us to be of considerable interest. We supposed that they would give the E.M.F. of their most positive constituent. This, however, is not always the case. Solder gives a deflection of 40 (lead = 40, tin = 32), but brass gives the same deflection as copper, namely, 33. A confirmation of this is the fact that brass and copper give no E.M.F. in dilute sulphuric acid.

After having made these experiments with the iodine cell, we made a chlorine cell by filling the porous pot with a freshly prepared solution of chlorine. The results with the chlorine cell do not agree well with the results found in the cuprous chloride cell, and the heats of combination calculated from the electromotive forces in the chlorine cell must be regarded as very rough approximations. Two values are worth mentioning. The heat of combination of 1 gramme of zinc with chlorine, calculated from its E.M.F.

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* At the time this paper was read we had not seen Naumann's *Thermochemie* (published 1882). The above values have therefore been inserted since then. They are much nearer our own than the values given in the older books.

in the chlorine cell, is 1578 heat units. The number given by Naumann is 1736 heat units. Naumann's value, with a correction which has not been made for the heat of solution of chlorine, is about 1660 heat units. The heat of formation of $Cu_2 Cl_2$ from the E.M.F. of copper in the chlorine cell is 493 heat units. The number given by Naumann is 517 heat units.

We have made a few experiments with a bromine cell, but as we have not made any with a copper bromide cell, it is unnecessary to give them at present.

One experiment is mentioned in this paper, testing the influence of temperature on the E.M.F. of the iodine cell. This has become a matter of some importance. In a paper by Helmholtz, to which we referred in our last communication, it is shown that the difference of E.M.F. at different temperatures is possibly the measure of the work done in the cell which does not appear in the electric current.

In conclusion, the results derived from the iodine and cuprous iodide cell seem fairly satisfactory.

Probably the best way to test the accuracy of the method would be to run down an iodine cell in a calorimeter, and compare the heat evolved by the solution of a given weight of zinc with the value calculated from the electromotive force of the cell. We propose to make some experiments in this direction.

6. On the Nature of Solution. By Mr. W. L. Goodwin. Communicated by Professor Crum Brown.

7. Diagnoses plantarum novarum et imperfecte descriptarum Phanerogamarum Socotrensium, quas elaboravit Bayley Balfour, Scientiæ Doctor et in Universitate Glascuensi rerum botanicarum regius professor. Pars Altera.

RUBIACEÆ.

58. **Dirichletia venulosa**, *Balf. fil.*: frutex 10-pedalis; foliis oblongis v. oblongo-lanceolatis basi angustatis vix petiolatis acutis v. obtusis coriaceis margine revolutis, subtus venulis nigris perspicuis

nervoque medio sparse puberulo; seta media stipulari lateralibus triplolongiori; floribus brevissime pedicellatis; fructu glabro disco prominulo convexo, calycis limbo expanso foliaceo panduriformi nigro-venuloso nitido.

Socotra, in montibus Haggier. B.C.S. No. 320. Schweinf. No. 616 ex parte.

59. Dirichletia lanceolata, *Balf. fil.*: frutex parvus ramulis tomentosis; foliis lanceolatis v. elliptico-lanceolatis sessilibus v. subsessilibus vaginis amplis acutis coriaceis, supra subnitidis nervis puberulis, subtus pubescentibus; cuspide media stipulari lateralibus triplolongiori; floribus breviter pedicellatis; fructu pubescente disco parum convexo, calycis limbo expanso elliptico acuto foliaceo coriaceo puberulo.

Socotra, in montibus Haggier infrequens. B.C.S. No. 422.

60. Dirichletia obovata, *Balf. fil.*: frutex 10-pedalis; foliis obovatis breviter petiolatis truncatis emarginatis sæpe mucronatis rarissime acutis crassiusculis coriaceis, supra nitidis, venulis ultimis inconspicuis, margine obscure ciliatis; seta media stipulari lateralibus duplolongioribus; floribus capillariter pedicellatis; fructu glabro disco plano, calycis limbo expanso membranaceo pellucido-punctulato venuloso nitido.

Socotra, frequens. B.C.S. Nos. 172, 592. Schweinf. No. 250.

Placopoda, *Balf. fil.*

Calycis tubus parvus, obconicus; limbi lobi 4, breves acut, æquales, persistentes, dentibus minutis fere obsoletis interjectis. Corolla tubulosa, tubo brevi intus piloso; limbi lobi 4, breves, triangulares, valvati. Stamina 4, infra faucem corollæ inserta, filamentis brevibus, subulatis; antheræ inclusæ, dorso affixæ, lineari-oblongæ, utrinque obtusæ. Discus tumidus, crenatus, glaber. Ovarium 2-loculare; stylus filiformis, exsertus, ramis 2 undique papillosis; ovula in loculis pauca 2–3, in apice placentæ carnosæ columnaris a basi loculi adscendente sessilia. Fructus corneus, indehiscens compresso-campanulatus, parum bialatus, lateribus trinerviis nervis elevatis, 2-locularis, loculis 1-spermis. Semina verticalia, oblonga, obtusa, cylindracea, testa minute corrugata, albumine carnoso; cotyledones angustæ; radicula teres.—Suffrutices ramosi, ramulis 4-gonis, pubescentes proventu glabri. Folia parva, petiolata, subcrassa, ovali-oblonga, in ramulis brevissimis verticillatis fasciculata. Stipulæ minutissimæ. Flores in cymas umbellatas simplices terminales dispositi.

Genus monotypicum *Dirichletiæ* valde affine.

61. P. VIRGATA, *Balf. fil.*: species unica in campis crescens. B.C.S. No. 25. Schweinf. No. 476.

62. HEDYOTIS STELLARIOIDES, *Balf. fil.*: erecta annua tenuis, caule tetraquetro scabridulo; foliis remotis subsessilibus elliptico-oblongis v. trapeziformibus v. sublanceolatis acutis revolutis subciliatis; stipulis 2–3-dentatis; cymis terminalibus spurie abortu dichotomis; pedicellis filiformibus rigidis longis; floribus parvis albis; stylo integro capitato; fructu non-exserto capsulari pyriformi septicide ad basin bivalim fissente carpellis ventraliter dehiscentibus.

Socotra, apud clivos montium frequens. B.C.S. No. 313. Schweinf. No. 800.

63. MUSSÆNDA CAPSULIFERA, *Balf. fil.*: arbor parva ramis juvenilibus tetragonis pubescentibus; foliis oblongo-ellipticis v. obovatis acutis v. obtusis basi contractis subsessilibus coriaceis fere glabris; stipulis dentatis, floribus in rigidas erectas terminales cymas dispositis; calycis lobis æqualibus foliaceis linearibus; corolla elongata, limbis obcuneatis; fructu sicco loculicide dehiscente.

Socotra, in montibus Haggier. B.C.S. No. 550. Schweinf, No. 455.

64 GAILLONIA (MICROSTEPHUS) TINCTORIA, *Balf. fil.*: a collo radicis tortuose ramosa, ramis nigris, internodiis brevibus puberulis; foliis classis anguste spathulatis, sparse et brevissime puberulis; stipulis polymorphis; floribus solitariis axillaribus breviter pedicellatis; calyce 5-lobato, lobis 2 magnis, 2 minoribus, 1 mimino; corolla extus scabridula; stylo longe exserto.

Socotra, prope Gollonsir. B.C.S. No. 321.

65. GAILLONIA PUBERULA, *Balf. fil.*: suffrutex rigidus dichotome

ramosus puberulo-tomentosus internodiis elongatis; foliis inferioribus lanceolatis v. oblanceolatis v. obovatis acutis v. obtusis revolutis sparse puberulis, superioribus linearibus; stipulis polymorphis; floribus axillaribus v. terminalibus solitariis v. in cymas trifloras dispositis; calycis dentibus subæqualibus non-accrescentibus; corolla extus pubescente; staminibus sæpius inæqualibus; stylo incluso; fructu dentibus calycis coronato dense hirsuto.

Socotra, frequens. B.C.S. No. 155. Schweinf. No. 602.

66. **Gaillonia (Microstephus) thymoides**, *Balf. fil.*: suffruticosa parva rigida dense dichotome ramosa, ramis strictis divaricatis scabrido-puberulis; foliis petiolatis oblongo-ellipticis v. lanceolatis obtusis v. acutis revolutis scabro-puberulis, oppositis, sæpe in basin ramorum confertis; stipulis heteromorphis; floribus axillaribus solitariis brevissime pedicellatis; calyce 5-lobato, lobis 3 magnis subulatis, 2 parvis hirsutis; corolla extus puberula; stylo exserto; fructu hirsuto.

Socotra, frequens. B.C.S. No. 187. Schweinf. No. 254.

VALERIANACEÆ.

67. **Valerianella affinis**, *Balf. fil.*: herba pusilla tenuis sparse bipartim ramosa; foliis inferioribus oblongo-ellipticis v. oblanceolatis obtusis obscure dentatis, superioribus sæpe linearibus remote acuteque dentatis v. interdum trifidis; cymis paucifloris, bracteis scarioso-marginatis; calyce rotato-campanulato herbaceo utrinque glabro reticulato-venuloso 6-fido, lobis uncinulatis inæqualibus; capsulis calyci æquilongis puberulis antice obcuneatim sulcatis, in loculo fertili parum maximo lateraliter extenso, loculis sterilibus subteretibus.

Socotra, in montibus prope Gollonsir. B.C.S. No. 551.

COMPOSITÆ.

68. **Vernonia Cockburniana**, *Balf. fil.*: frutex plus minusve canescens ramis sæpe virgatis sed plurimis lateralibus abbreviatis; foliis obovatis obtusis v. emarginatis integris remotis v. in apices ramorum contractorum fasciculatis; capitulis majusculis 10–13-floris solitariis v. 2–3 in cymas in apices ramorum lateralium dispositis; phyllariis multiseriatis obtusis ciliatis extus pubescentibus, interiori

bus persistentibus; achæniis 6–9-costatis intervallis sessili-glandulosis pilisque suffultis; pappo exteriore squamiformi brevi.

Socotra, frequens. B.C.S. No. 261. Schweinf. No. 513.

69. Psiadia Schweinfurthii, *Balf. fil.* : suffruticosa glaucescens non glutinosa; foliis lanceolatis petiolatis acutis integris v. supra obscure dentato-serratis glanduloso-puberulis crassiusculis; capitulis parvis copiose paniculato-corymbosis; phyllariis 5-seriatis exterioribus glanduloso-puberulis, internis glabris; stylis exsertis; achæniis pilis adscendentibus vestitis; pappi setis basi connatis.

Socotra, prope Kischen. Schweinf. No. 606.

70. Pluchea glutinosa, *Balf. fil.*: suffruticosa glutinosa glabra: foliis oblanceolatis v. lanceolatis breviter petiolatis integris v. in parte superiore dentatis glanduloso-punctatis; capitulis multifloris parvis 3–4 sessilibus v. subsessilibus in apices ramorum multo v. pauci-ramosi terminalis v. pseudo-terminalis paniculati corymbi; phyllariis extimis squamiformibus apiculatis, intimis linearibus subscariosis; antheris obtusis; stylo indiviso; achæniis pilis adscendentibus vestitis; pappo squamiformi.

Socotra, in montibus. B.C.S. No. 616. Schweinf. No. 646.

71. Pluchea aromatica, *Balf. fil.*: fruticosa aromatica; foliis lanceolatis v. elliptico-oblongis acutis petiolatis integris v. in parte superiore obscure dentato-serratis ciliatis glanduloso-scabridis; capitulis longe pedunculatis multifloris terminalibus v. axillaribus solitariis rarius in cymam dispositis; phyllariis extimis brevissimis glandulosis apice reflexis, intimis angustissimis glabris; antheris acuminatis; stylo bifido, lobis complanatis; achæniis glabris; pappo squamiformi.

Socotra, in montibus Haggier supra Tamarida et Kischen. B.C.S. No. 465. Schweinf. No. 631.

72. Pluchea obovata, *Balf. fil.*: fruticosa aromatica sæpe procumbens; foliis obovatis v. obcuneatis v. oblanceolatis sessilibus integris v. in parte superiore dentatis glabris glanduloso-punctatis; capitulis breviter pedunculatis multifloris terminalibus v. axillaribus solitariis v. in 2–3-capitatas cymas dispositis; phyllariis exterioribus

brevioribus glanduloso-lanato-puberulis erectis, interioribus angustissimis glabris; antheris obtusis; stylo bifido, lobis teretibus papillosis; achæniis costis pilis adscendentibus vestitis; pappo setiformi.

Socotra, in scopulis montium altiorum. B.C.S. No. 497. Schweinf. No. 764.

73. **HELICHRYSUM SPHÆROCEPHALUM**, *Balf. fil.*: lignosum lanatum parvum a basi ramosum ramis diffusis compressis; foliis 5-nerviis obovatis, basalibus breviter petiolatis, superioribus subsessilibus; capitulis campanulatis 30–40-floris brevissime pedicellatis 20–25 in cymas globosas terminales solitarias glomeratis; phyllariis multiseriatis, interioribus in parte superiore niveo-petaloideis patentibus floribus longioribus glabris; receptaculo nudo; achæniis scabridulis.

Socotra, in montibus altissimis Haggier. B.C.S. No. 79. Schweinf. No. 629.

var. sarmentosum, *Balf. fil.*: quasi stoloniferum; foliis majoribus angustioribus suboblanceolatis v. spathulatis; capitulis 15–20-floris; 50–60 in cymas $\frac{5}{6}$ poll. diam. glomeratis; phyllariis interioribus floribus brevioribus.

Socotra, cum forma typica sed in locis nudis. B.C.S. No. 79 bis.

74. **HELICHRYSUM ARACHNOIDES**, *Balf. fil.*: annuum parvulum ramosum plus minusve arachnoideo-lanatum; foliis remotis ellipticis, inferioribus petiolatis, superioribus subsessilibus; capitulis parvis 8–12-floris campanulatis brevissime pedicellatis 7–8 in cymas terminales (rarius axillares) congestas glomeratis; phyllariis biseriatis, interioribus ad apicem niveis post anthesin patentibus; receptaculo nudo; achæniis scabriusculis.

Socotra, in montibus prope Gollonsir. B.C.S. No. 197.

75. **HELICHRYSUM ACICULARE**, *Balf. fil.*: suffruticosum ericæphylloideum procumbens v. cæspitosum glabrescens; capitulis obconoideis 40–50-floris breviter pedicellatis 3–5 ad apices pedunculorum solitariorum axillarium longorum breviter lanatorum dispositis; phyllariis glabris omnibus fulvo-stramineis; receptaculo nudo; achæniis puberulis.

Socotra, in summis montibus Haggier. B.C.S. No, 397. Schweinf No. 561.

76. **Helichrysum suffruticosum**, *Balf. fil.*: suffrutex plus minus glanduloso-pubescens; foliis sessilibus, inferioribus cochleariformibus, superioribus panduriformibus; capitulis parvis campanulatis 20-floris pedicellatis in corymbas terminales dispositis; phyllariis glabris concoloribus fulvo-stramineis; receptaculo nudo; achæniis puberulis.

Socotra, in montibus Haggier. B.C.S. No. 406. Schweinf. No. 628.

77. **Pulicaria diversifolia**, *Balf. fil.*: herba scabrido-hirsuta ramis in capitula solitaria abeuntibus; foliis basalibus plerumque ab formis obcuneatis ad oblanceolatas basique gradatim attenuatis interdum ellipticis v. oblongo-ellipticis basique abrupte contractis, infra integris, supra grosse dentato-serratis v. crenatis, acutis v. obtusis, petiolo longo anguste alato subamplexicauli, caulinibus angustioribus; capitulis hemisphæricis multifloris radiatis; phyllariis subæqualibus lineari-acuminatis glanduloso-hirsutis; achæniis 7–8-costatis hirsutis; pappo exteriore coroniformi, setis interioribus 10.

Socotra, in campis communis. B.C.S. Nos. 119, 600. Schweinf. No. 453.

78. **Pulicaria stephanocarpa**, *Balf. fil.*: fruticosa tortuose ramosissima glaucescens; foliis crassis velutinis spathulatis v. cochleariformibus plus minusve 3–5-rotundato-lobatis persistentibus; capitulis homogamis solitariis axillaribus breviter pedunculatis; phyllariis exterioribus gradatim minoribus; antherarum caudis elongatis connatis simplicibus; achæniis angulatis 10-costatis corona setarum ad apicem sub pappo suffultis; pappo exteriore cupuliformi segmentis paleaceis, interioribus setis complanatis.

Nom. vern. Dheel.

Socotra, in campis calcareis occidentalibus et australibus abundans. B.C.S. No. 14. Schweinf. No. 252.

79. **Pulicaria vieræoides**, *Balf. fil.*: fruticosa cinerea habitu Vieræeæ; foliis obovatis crasse coriaceis glandulis instructis et arachnoideis; capitulis radiatis solitariis pseudo-terminalibus longe pedunculatis; phyllariis, pauciseriatis glanduloso-puberulis exterioribus

gradatim minoribus extimisque sæpe foliaceis magnis; antherarum caudis elongatis simplicibus connatis; achæniis subteretibus 10-costatis apice hirsutis; pappo exteriore cupuliformi paleaceo-lacero, interioribus setis complanatis.

Socotra, in montibus Haggier prope Tamarida. B.C.S. Nos. 402, 481.

80. Senecio (Kleinia) Scotti, *Balf. fil.*: perenna erecta glabra succulenta multo-ramosa, caulibus subteretibus; foliis remotis parvis linearibus; capitulis subcylindricis homogamis 6–8-floris ad extremitates ramorum solitariis v. 2–3 in cymas breviter pedunculatas aggregatis; phyllariis 5–6 linearibus cuspidatis floribus dimidio brevioribus; receptaculo nudo; achæniis subteretibus 10-costatis brevibus rigidis setulis intercostalibus; pappo corollæ vix æquilongo.

Socotra, in montibus Haggier prope Tamarida. B.C.S. No. 446.

81. Euryops socotranus, *Balf. fil.*: suffrutex 3-pedalis glaber bipartim ramosus ramis cicatricosis; foliis sessilibus arcte trifidis, segmentis linearibus obtusis; pedunculis foliis vix æquilongis; phyllariis 8 connatis; achæniis hispidis.

Socotra, in montibus altissimis Haggier. B.C.S. No. 401. Schweinf. No. 673. Hunt. No. 11.

82. Dicoma cana, *Balf. fil.*: prostrata cano-tomentosa lignosa; foliis linearibus obtusis sessilibus crassis persistentibus; capitulis solitariis pseudo-terminalibus subsessilibus paucifloris homogamis discoideis; phyllariis pallidis glabris, intimis membranaceis, exterioribus gradatim minoribus rigidis subulato-punctatis; receptaculo alveolato; achæniis dense setosis; pappi setis conformibus serrulato-barbellatis.

Socotra, in montibus prope Gollonsir. B.C.S. No. 757.

83. Lactuca rhynchocarpa, *Balf. fil.*: herba tenuis glabra depressa v. a basi ramosa caulibusque suberectis; foliis glaucis lyrato-pinnatipartitis, segmento terminali oblongo-acuto v. rotundato v. panduriformi subaculeato-dentato, segmentis inferioribus gradatim minoribus runcinatis, radicalibus breviter petiolatis subamplexicaulibus, caulinibus sessilibus; capitulis parvis 10–12-floris $\frac{2}{5}$ poll.

longis oppositifoliis in laxos pseudo-racemos dispositis; phyllariis intimis ensiformibus obtusis post anthesin vix basi incrassatis, extimis parvis ovato-acutis; achæniis vix compressis 4-gonis costis 1–2 in quoque facie conspicuis, infra angustatis, apice in rostrum longum abrupte productis; pappi setis serrulatis.

Socotra, in campis. B.C.S. Nos. 217, 595. Schweinf. No. 398.

84. **Lactuca crassifolia**, *Balf. fil.*: herba perenna glabra glauca valida divaricatim breviter ramosa; foliis crassiusculis lyrato-pinnatifidis, segmento terminali oblongo-acuto v. obtuso calloso-dentato et sæpe inæqualiter lobato, lobis inferioribus irregulariter ad basin minoribus, radicalibus vix petiolatis amplexicaulibus, caulinibus sessilibus auriculatis; capitulis 20-floris $\frac{1}{4}$–$\frac{1}{2}$ poll. longis oppositifoliis in pseudo-racemos breves dispositis; phyllariis intimis æqualibus linearibus marginatis, extimis paucis late ovatis minoribus; achæniis basi truncatis in rostrum breve pallidum productis; setis pappi scabridulis achæniis æquilongis.

Socotra, in campis. B.C.S. No. 595.

85. **Prenanthes amabilis**, *Balf. fil.*: herba perennis cano-lanuginosa caule erecto in inflorescentiam abeunte; foliis lyrato-runcinatis, lobo terminali rotundato v. acute lobato parte inferiore sæpe angustissimo, amplexicaulibus axillariter lanato-villosis membranaceis glabris; capitulis longe pedunculatis 5–6-floris in laxe ramosas paniculas dispositis; phyllariis intimis 5–6 linearibus acutis, exterioribus brevibus; achæniis tetragonis truncatis basi angustatis pappo sordido setoso serrulato brevioribus.

Socotra, in montibus prope Gollonsir. B.C.S. No. 311.

86. **Launæa crepoides**, *Balf. fil.*: herba rosulata glabra perennis; foliis spathulatis v. oblanceolatis basi longe attenuatis obtusis integris; capitulis solitariis in apices scaporum longorum bracteolatorum v. in laxas 2–3-ramosas cymas dispositis; phyllariis intimis 8 linearibus; calyculi squamis paucis ovatis herbaceis; styli lobis setulis nigris suffultis; achæniis linearibus subfusiformibus multocostatis rugosis; pappo exteriore lanoso-intricato, intimo setoso.

Socotra, in montibus non infrequens. B.C.S. No. 307. Schweinf. No. 570.

The Chairman read the following Review of the Session :—

In announcing the close of our Hundredth Session, I have to congratulate the Society on the gratifying fact that, though it has attained this advanced age, it shows no symptoms of decrepitude or senility.

But though the Society as an institution is prosperous and never dies, a retrospect on an occasion like this reminds us that the members of which it is composed are transitory—

> Noctes atque dies patet atri janua Ditis.

Since the commencement of the session fifteen of our Fellows have passed away. Among these are included men of the highest rank in science, like Dr. Darwin, Sir Wyville Thomson, and Dr. Romney Robinson; illustrious physicians like Sir Robert Christison and Sir John Rose Cormack; and great surgeons like Professor Spence; eminent literary men like Dr. John Brown; great scholars like Dr. John Muir and Sheriff Hallard. The Society, besides, has lost a distinguished engineer in John Scott Russell, and a distinguished artist in Sir Daniel Macnee.

Many of these were regular attenders at our meetings. With most of them I was on familiar terms. It was our privilege to listen to the papers that they read in this place. How painful it is to me, how painful must it be for you, to miss in the course of a few months their thoughtful but cheerful countenances and their pleasant presence. But the services which men like these render to science and to this Society fortunately cease not with their lives. By their labours they have removed obstacles from the path of others in all time coming, and the inspiration of their example will stimulate their survivors to make similar efforts, which may be crowned with similar success.

On this occasion I cannot but remember what a long interval has elapsed since I joined the Society in 1835. I look back with pleasure on the forty-eight years during which I have attended your meetings, and the nineteen years during which I acted as General Secretary of the Society.

On looking back on what has been done by our members during the session, I find that there have been twenty-five papers read on subjects connected with Natural Philosophy; seven have dealt with Mathematical subjects; nine relate to Geology; seven are Chemical; seven in the department of Natural History; four in the department of Botany; six relate to Physiology; two relate to Mineralogy; and two to Literature; while Antiquities, Astronomy, and Meteorology have each had one paper devoted to them.

I think that those who have paid most attention to the work accomplished during the session that now comes to a close, will agree with me in holding that the papers that have been read, while fully equal, on the whole, to those of any previous session, show in some departments a marked and gratifying advance.

Donations to the Library of the Royal Society during Session 1879–80.

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INDEX.

Absorption of Sea-Water, by John Aitken, 637.

Adamantine Carbon or Diamond: Its Preparation, by Dr. R. S. Marsden, 20.

Addresses:—

- Introductory Address (Session 1880–81), by the Right Hon. Lord Moncreiff, 136.
- Address on the Island of Socotra, by Professor I. Bayley Balfour, 245.
- Address on Closing the Session 1880–81, by Sir Alexander Grant, Bart., 293.
- Address by David Milne Home, on presenting the Makdougall-Brisbane Prize to Professor Piazzi Smyth, Astronomer-Royal for Scotland, 362.
- Address on the Historic Evidence for the Destruction of Pompeii and Herculaneum, by Dr. Cazenove, 421.
- Address by Professor Tait, on presenting the Keith Prize to Professor Chrystal, 797.
- Address by Mr. Buchan, on presenting the Neill Prize to Mr. John Murray, 797.
- Address on Closing the Session 1881–82, by Professor J. H. Balfour, 843.

Agassiz (Professor A.), Report on the Echinoidea of the Faroe Channel, 697.

Aitchison (Dr. J. E. Tierney) elected a Fellow of the Society, 233.

Aitken (Dr. A. P.), and Hamilton (Prof. D. J.), Report on Louping-ill and Braxy, 615.

Aitken (John) on Dust, Fogs, and Clouds, 14, 122.

Aitken (J.) on the Colour of the Mediterranean and other Waters, 472.

——— on the Absorption of Sea-Water, 637.

Algebra of Relationship, by Dr. Alexander Macfarlane. Part II., 5; Part III., 162.

Ammonium Salts, their Condition when dissolved in Water, by W. W. J. Nicol, 819.

Amœboid Movements, by John B. Haycraft, 29.

Ampelideæ Socotrenses, 506.

Ampelisca compacta, New Species of Crustacean, 688.

Anacardiaceæ Socotrenses, 507.

Anglin (A. H.), M.A., M.R.I.A. elected a Fellow of the Society, 133.

——— on the Expansion of Rational Fractions, 162.

Annelida of the Faroe Channel, by Dr. M'Intosh, F.R.S., 693.

Anurella, a Sub-Family or Section of the *Molgulidæ anuræ*, 233; Anurella and Molgula, in classifying the "Challenger" species, considered as one genus, 234.

Arrangement.—Additional Note on a Problem of Arrangement, by Thomas Muir, A.M., 187.

Article, the Definite, in Greek, by Professor Blackie, 622.

Articulation, by the Rev. J. L. Blake, 815.

Ascopera, a New Genus of the Molgulidæ, 234.

——— *gigantea*, new species, 238.

——— *pedunculata*, new species, 239.

Asteroidea of the Faroe Channel, by W. P. Sladen, F.L.S., 698.

Atmospheric Electricity, by Professor C. Michie Smith, 613.

Atmospheric Refraction, Professor Vince's Two Cases of, 581.

Atomicity (Chemical), by William Durham, 231.

Avicennia officinalis, by Dr. Joseph Bancroft, 456.

Bacillus anthracis resembles the Bacillus of Braxy, 621.

Balænoptera borealis or *laticeps*, by Professor Turner, 515; its Spine, 519; its Skull, 523; its Pectoral Limb, 526.

Balfour (Professor I. Bayley), Address on the Island of Socotra, 245.

——— Diagnoses Plantarum Novarum et imperfecte descriptarum Socotrensium, Fungorum, Algarum, Lichenum, 456, 498.

——— Diagnoses Plantarum Novarum et imperfecte descriptarum Phanerogamarum Socotrensium, 834.

Balfour (Dr. J. H.) contributes Obituary Notice of Dr. P. D. Handyside, 329.

——— Address on Closing the Session 1881–82, 843.

Ballengeich Boulder, 266.

Bancroft (Dr. Joseph) on Respiration in the Roots of *Avicennia officinalis* 456.

Barnes (Dr. Henry) elected a Fellow of the Society, 514.

Baryta (Caustic), its action on Acid Sulphate of Tetra-Benzyl-Phosphonium, 48.

Battery (Iodine), by A. P. Laurie, 230.

Beddard (Frank E.), B.A., and Geddes (Patrick), on the Histology of the Pedicellariæ and the Muscles in *Echinus sphæra* (Forbes), 88.

——— on the Anatomy of the Nervous System of the Pond Snails Planorbis and Lymnæus, 576.

——— on the Anatomy and Histology of *Pleurochæta Moseleyi*, 629.

Ben Nevis.—The Application of the Rocks of Ben Nevis to Ornamental Art, 365.

Berry (Walter), Danish Consul-General, elected a Fellow of the Society, 233.

Betaines.—On Phosphorus Betaines, by Professor E. A. Letts, 40.

Bismutho-hypobismuthic Oxide, 566.

Bismuth, an Oxycyanide of, and a New Oxide of, by M. M. Pattison Muir, 557.

Blackie (Professor J. S.) on the Definite Article in Greek, with special reference to the Revised Version of the New Testament, 622.

Blake (Rev. J. L.) on Voice-Effort and Rhythm, 798.

——— on Vocalisation and Articulation, 815.

Blood - Corpuscles. — Some Physical Experiments bearing upon the Circulation of the Blood-Corpuscles, by Professor D. J. Hamilton, 370.

Blyth (Professor James), Note on an Electric Sonometer, 28.

——— on a Simple Form of Selenium Cell, 119.

——— on the Cause of Sounds produced in the Microphone Receiver, 206.

——— on the Action of the Microphone, 622.

Bolteninæ, a Sub-Family of the Cynthiadæ, 53.

Boltenia elegans, new species, 80.

——— *legumen*, 81.

——— *pachydermativa*, new species, 81.

Boreomysis nobilis, 687.

Boulders.—Seventh Report of the Boulder Committee, 246; Eighth Report of the Boulder Committee, 743.

Bourget (Lake of), the Colour of its Waters, 478.

Brady (H. B.), Report on the Foraminifera of the Faroe Channel, 708.

Braxy, Report on, 615, 620.

Brotherston on the Cause of Sheep Disease, 616.

Brown (Professor Crum) on Chemical Nomenclature and Notation, 211.

——— proposes an amendment to Law XIV., that the words *December to July* be substituted for the words *November to June*, 421.

——— on a Case of Dyspeptic Vertigo, 594.

Brown (J. A. Harvie) of Dunipace elected a Fellow of the Society, 133.

Buchan (A.) M.A. Address on presenting the Neill Prize to John Murray, 797.

Buchanan (George): His Treatise "De Jure Regni apud Scotos" in connection with the Dawn of the Constitutional Principle, by Lord Moncreiff, 137; Short Biography of, 138.

Buchanan (J. Y.), on a Solar Calorimeter, and some Observations made with it in Upper Egypt, 827.

Buchanan (J. Y.) on the Oxidation of Ferrous Salts, 191.

Buchanan (T. R.), M.P., elected a Fellow of the Society, 637.

Burseraceæ Socotrenses, 505.

Burton (C. J.) and Laurie (A. P.), the Heats of Combination of the Metals with the Halogens, 804, 830.

Burton (John Hill), LL.D., D.C.L., F.R.S.E., Obituary Notice of, by J. Gordon, assistant librarian, 324.

Busk (Dr. G.), Report on the Polyzoa of the Faroe Channel, 690.

Caliciew Socotrenses, 457.

Calorimeter, a Solar, by J. Y. Buchanan, 827.

Cameron (A. J. D.), elected a Fellow of the Society, 233.

Campbell (Albert), Change in the Peltier effect due to Variation in Temperature, 807.

Candle-power of Swan's Lamp, by A. Jamieson, 615.

Canna: Its Leaf-bed, by Professor Heddle, 630.

Capparideæ Socotrenses, 501.

Carbon (Adamantine) or Diamond: Its Preparation, by Dr. R. S. Marsden, 20.

——— Its State in Iron and Steel: a New Hypothesis of the Hardening of Iron and Steel, by Dr. R. Sydney Marsden, 368.

Carboniferous Rocks of the South of Scotland, by Archibald Geikie, F.R.S., 598; The Crustacea and Scorpions of, by B. N. Peach, 603.

Caryophylleæ Socotrenses, 501.

Cay (W. Dyce), Memb. Inst. C.E., elected a Fellow of the Society, 598.

Cayley (Professor), His Theorem regarding a Bordered Skew Determinant, by Thomas Muir, M.A., 187.

Cazenove (Rev. Dr.) delivers an Address on the Historic Evidence for the Destruction of Pompeii and Herculaneum, 421.

Cells.—Yellow Cells of Radiolarians and Cœlenterates, 377.

——— The Vegetable Cell, by J. M. Macfarlane, 576.

Channel between Scotland and the Faroe Islands: Its Physical and Biological Conditions, 233, 638, 720.

Chase (Pliny Earle), His $\frac{\pi^n}{32}$ Series represents Professor George Forbes' Hypothetical Planets, 93.

Chemical Affinity and Atomicity, by William Durham, 231.

Chemical Nomenclature and Notation, by Professor Crum Brown, 211.

Chloracetic Acid: Its action on Triethylphosphine, 41.

Christie (Rev. George), Report as to Boulders in Lunnasting, 747.

Christison (Sir Robert), Bart., Hon. V.-P., on the Application of the Rocks of Ben Nevis to Ornamental Art, 365.

——— The loss sustained by the Society through his Death adverted to, 421.

Chrystal (Professor), Remarks on Dielectric Strength, 487.

——— awarded the Keith Prize for 1879-81, 743; the Prize presented, 797.

Cist discovered at Parkhill, Aberdeenshire, 405.

Clouds.—On Dust, Fogs, and Clouds, by John Aitken, 14.

Coats (Sir Peter) elected a Fellow of the Society, 361.

Cockburn (Charles), Fungi et Algæ in Socotra, 456.

Cœlenterates and Radiolarians—their Yellow Cells, 377.

Collemeæ Socotrenses, 457.

Collie (N.), and Professor Letts, on the Action of Haloid Compounds of Hydrocarbon Radicals on Phosphide of Sodium, and on the Salts of Tetra-benzyl-phosphonium, 46.

Comenic Acid, by D. B. Dott, 241.

Como, the Lake of; the Colour of its Waters, 477.

Compositæ Socotrenses, 837.

Compression, Temperature Changes caused by, 51.

Constitutional Principle, the Rise of, by Lord Moncreiff, p. 136.

Cooke (Dr M. C.), Diagnoses Fungorum Novorum in Insula Socotra, 456.

Cornuspira crassisepta, 714.

——— *involvens*, 714.

——— *striolata*, 713.

Council for Session 1880–81, 1; for Session 1881–82, 324.

Crassulaceæ Socotrenses, 512.

Cristellaria reniformis, 716.

Cruciferæ Socotrenses, 500.

Crooked Stone Boulder, 268.

Crystallization of Silica from Fused Metals, by Dr. R. Sydney Marsden, 37.

Ctenicella, a Genus of the Molgulidæ, 233, 234.

Cubic (Symbolic).—A Particular Case of the Symbolic Cubic, by Dr Gustav Plarr, 342.

Cucurbitaceæ Socotrenses, 513.
Culeolus, New Genus of the Cynthiadæ, 82.
——— *Moseleyi*, new species, 87.
——— *Murrayi*, new species, 83.
——— *perlucidus*, new species, 86.
——— *recumbens*, new species, 85.
——— *Suhmi*, new species, 86.
——— *Wyville-Thomsoni*, new species, 84.
Cumming (Rev. John), D.D., Obituary Notice of, by the Rev. Professor Flint, 328.
Cynthia, a Genus of the Cynthiadæ, 57.
——— *arenosa*, new species, 59.
——— *cerebriformis*, new species, 57.
——— *complanata*, new species, 62.
——— *irregularis*, new species, 60.
——— *fissa*, new species, 58.
——— *formosa*, new species, 58.
——— *hispida*, new species, 61.
——— *pallida*, Heller, 60.
Cynthinæ, a Sub-family of the Cynthiadæ, 53.

Determinants.—Transformations connecting General Determinants with Continuants, by Thomas Muir and Professor Chrystal, 135.
——— Mr Thomas Muir on Professor Cayley's Theorem regarding a Bordered Skew Determinant, 187; Law of Extensible Minors in Determinants, 187.
Dickie (Dr. G.), Diagnoses Algarum Novarum Socotrensium, 456.
Dielectric Strength, by Professor Chrystal, 487.
Dimethyl-thetine, 41.
Dirichletiæ Socotrenses, 834.
Dittmar (Professor), Report on Gas Contents of Water of Faroe Channel, 718.
Dixon (J. A.) elected a Fellow of the Society, 622.
Dobbie (Dr. J. J.), M.A., and G. C. Henderson, B.Sc., on the Formation of Serpentine from Dolomite, 606.
——— on a Red Resin from *Dracæna Cinnabari*, Socotra, 798.
Dobbin (Dr. Leonard) elected a Fellow of the Society, 202.
Donations of Books from Scientific and Literary Societies, and from Authors, 845.
Dott (D. B.) elected a Fellow of the Society, 421.
——— Comenic Acid 241.
——— Meconic Acid, 83.
Dracæna Cinnabari, Socotra, 798.
Duns (Professor), The Surface Geology of Mid-Lochaber, 483.
——— on Boulders at Mid-Lochaber, 761.
Durham (William), Note on Chemical Affinity and Atomicity, by William Durham, 231.
Dust, Fogs, and Clouds, by John Aitken, 14; If there was no dust, there would be no fogs, no clouds, and probably no rain, 15; Dust-motes may be removed by heat, and yet the air may produce clouds, 16; Part II., 122.
Dust-Particles form the Nucleus on which Vapour Condenses, 15.
Dyspeptic Vertigo, A Case of, by Professor Crum Brown, 594.

Earthquake of 28th November, 1880, in Scotland and Ireland, by Charles Alexander Stevenson, 176.
Earth's Rotation, Thermodynamic Acceleration of, by Sir William Thomson, 397.
Echinoidea of the Faroe Channel, by Professor A. Agassiz, 697.
Echinus sphæra (Forbes), The Muscles in, by Patrick Geddes, F.R.S.E., and F. E. Beddard, B.A., F.R.S.E., 88.
Eclipse (Solar) of 31st December 1880, by Edward Sang, 18.
——— of 17th May 1882, with Remarks on the Calculation, by Edward Sang, 720.
Eigg: Its Pitchstone-Porphyry River, by Professor Heddle, 632.
Electricity (Atmospheric), by Prof. C. Michie Smith, 613.
Electric Conductivity, Effects of Strain on, 135.
Electric Discharge Through Colza Oil, by Dr. Alex. Macfarlane, 293.
Electric Discharge, The Effect of Flame on, and the Effect of Moisture on, by Dr. A. Macfarlane and D. Rintoul, 567, 801.
Electric Sonometer, by Prof. James Blyth, 28.
Equidistant Multiples of Irrational Quantities, by E. Sang, 2.
Eoscorpius, a Genus of Scorpion, 245.
Eskdale, Carboniferous Rocks of, by Archibald Geikie, F.R.S. 600; Additional Fossil Fishes of, by Dr. R. H. Traquair, 603; Fossil Plants of, by R. Kidston, 603.
Ethyl-chlorate of Triethyl-phosphorus-betaine, 42.
——— Action of Oxide of Silver on, 43.

Ethyl-chlorate of Triethyl-phosphorus-betaine, Action of Heat on, 44.
Eugyra Kerguelenensis, new species, 237.
Euplectella: Its Structure, 2.
Everett (Professor), Letter to Professor Tait on Mirage, 358; Note on Mirage, 361.

Faroe Islands.—On the Physical and Biological Conditions of the Channel between Scotland and the Faroe Islands, by Sir Wyville Thomson, 233.
Faroe Channel.—Exploration of, by Staff-Commander Tizard and John Murray, in the "Knight-Errant," 638; I. Introduction, 638; II. Origin and Objects of the "Knight-Errant" Investigations, 640; III. Narrative of the Cruise, 644; IV. Results, 648; Wyville Thomson's Ridge, 648; Temperature, 652; Surface Dredging, 654, 657; Its Minerals, Animals, &c., 658; On the Plateau surrounding North Rona and Sulisker, 657; Soundings, Dredgings, and Trawlings in the Warm Area, 660; Description of the Muddy Deposit, 662; List of the Animals taken in the Warm Area, 665; Dredgings and Trawlings in the Cold Area, 666; Its Minerals, &c., 669; List of the Animals taken in the Cold Area, 670; Soundings, Dredgings, and Trawlings on the Ridge, Minerals and Organisms, 671; List of the Animals taken on the Ridge, 673; Report on the Fishes, by Dr. A. Günther, F.R.S., 677; Report on the Mollusca, by Dr. Gwyn Jeffreys, F.R.S., 680; Report on the Crustacea, by Rev. A. M. Norman, 683; Report on the Pycnogonida, by Dr. P. P. C. Hoek, 689; Report on the Polyzoa, by Dr. G. Busk, F.R.S., 690; Report on the Annelida, by Dr. M'Intosh, F.R.S., 693; Report on the Holothurioidea, by Dr. Hjalmar Theel, 694; Report on the Echinoidea, by Professor A. Agassiz, 697; Report on the Asteroidea, by W. Percy Sladen, F.L.S., 698; Report on the Ophiuroidea, by Professor Theodore Lyman, 707; Report on the Foraminifera, by H. B. Brady, 708; Report on the Gas Contents of Sea Water, by Professor Dittmar, 718; Rocks of North Rona, by Professor A. Renard and John Murray, 720.
Ferguson (William), of Kinmundy, on a Cist discovered at Parkhill, Aberdeenshire, 405.
Ferrous Salts, The Oxidation of, by J. Y. Buchanan, 191.
Fishes of the Faroe Channel, by Dr. A. Günther, F.R.S., 677.
Flint (The Rev. Professor) Contributes Obituary Notice of the Rev. John Cumming, 328.
Focus of Object Glass, Easy Method for Determining the Position of, 50.
Fogs.—On Dust, Fogs, and Clouds, by John Aitken, 14.
——— More Perfect Combustion will remove the Pea-Soup character of Town Fogs, 18.
Foraminifera of the Faroe Channel, by A. B. Brady, F.R.S., 708.
Forbes (Prof. George), Additional Note on an Ultra-Neptunian Planet, 89.
——— Simple and Accurate Method of Determining the Longitude of a Place by a Single Observer, without measuring Time, 167.
Fossil Fishes of Eskdale and Liddesdale, by Dr. R. H. Traquair, 603.
Fossil Plants of Eskdale and Liddesdale, by Robert Kidston, 603; of Canonbie, 604.
Fraser (Professor T. R.), contributes Obituary Notice of Professor Sanders, 333.
Fungi.—Diagnoses Fungorum Novorum in Insula Socotra, a Bayley Balfour, C. Cockburn et A. Scott, lectorum, 456.

Galvanic Polarization, by Professor Helmholtz, 202.
Gases: Their Compression by High Pressures, by Prof. Tait, 293.
Geddes (Patrick) and Beddard (F. E.), on the Histology of the Pedicellariæ and the Muscles of *Echinus sphæra* (Forbes), 88.
——— on the Classification of Statistics, and its Results, 295.
——— on the Nature and Functions of the Yellow Cells of Radiolarians and Cœlenterates, 377.
Geikie (Archibald), F.R.S., on the Carboniferous Rocks of the South of Scotland, 598.
Geneva, The Lake of.—The Colour of its Waters, 477, 478.
Glass.—Crushing of Glass by Pressure, by Prof. Tait, 204.
Globigerina bulloides, 716.
Goodwin (W. L.), on the Nature of Solution, 834.

Gordon (James), contributes Obituary Notice of Dr. John Hill Burton, F.R.S.E., 324.
Government Grant for Scientific purposes, Statement by John Murray concerning, 806.
Grant (Sir Alexander), His Address on Closing the Session 1880-81.
Graphideæ Socotrenses, 465.
Gray (Thomas), elected a Fellow of the Society, 14.
——— on the Effect of Permanent Elongation on the Specific Resistance of Wires, 33.
Grove (The Hon. Justice), elected a British Honorary Fellow, 95.
Günther (Dr. A.), F.R.S., Report on the Fishes of the Faroe Channel, 677.

Halirages elegans, New Species of Crustacean, 688.
Hallard (Sheriff), contributes an Obituary Notice of Maurice Lothian, 99.
Halogens.—Heats of Combination of the Metals with the Halogens, by A. P. Laurie and C. J. Burton, 804, 830.
Haloid Compounds of Hydrocarbon Radicals: Their action on Phosphide of Sodium, and on Salts of Tetra-benzyl-phosphonium, by Prof. Letts and N. Collie, 46.
Hamilton (Prof. D. J.), M.B., elected a Fellow of the Society, 202.
——— Some Physical Experiments bearing upon the Circulation of the Blood-Corpuscles, 370.
——— and Aitken (Dr. A. P.), Report on Louping-ill and Braxy, 615.
Handyside (Dr. P. D.), F.R.S.E., Obituary Notice of, by Dr. J. H. Balfour, 329.
Haplophragmium tenuimargo, 715.
Harrington (James), His Oceana, in connection with the Dawn of the Constitutional Principle, 159.
Haycraft (Professor John B.) on Certain Movements exhibited by Low Forms of Animal Life, and termed Amœboid, 29.
——— on the Walls of Hepatic Cells, 131
Heat.—Heat Waves: Effects of Temperature-changes of Specific Heat and Conductivity on the Propagation of Plane Heat Waves, by Professor Tait, 126.
——— Simple Method of Showing the Diminution of Surface Tension in Water by Heat, by Professor Tait, 131.
Heat.—Its Action on Thioformanilid, 199.
——— Note on the Heating produced by Compression, by Professor Tait, 217.
Heats of Combination of the Metals with the Halogens, by A. P. Laurie and C. J. Burton, 804, 830.
Heddle (Professor Forster), Notes on Boulders in Dumfriesshire and the Highlands, 268.
——— Chapters on the Mineralogy of Scotland (chap. vii.), 549.
——— Geological Notes—Leaf-bed in Canna, 630.
——— The Pitchstone Porphyry River of the Scuir of Eigg, 632.
——— A Supposed Organism from the Marble of Sutherland, 634.
——— Notes on Boulders in Fife, the Lewis, and the Fort-William District, 772.
——— on the Order of Succession of Rocks in the North-West Highlands, 815.
Henderson (G. G.) B.Sc., and Dr. J. J. Dobbie, on the Formation of Serpentine from Dolomite, 606.
——— on a Red Resin from *Dracæna Cinnabari*, Socotra, 798.
Hepatic Cells: Their Cell-Walls, by Professor J. B. Haycraft, 131.
Herculaneum and Pompeii: The Historic Evidence for their Destruction, by the Rev. Dr. Cazenove, 421. See *Pompeii.*
Helmholtz (Professor) on Galvanic Polarization, 202.
Herdman (Dr. W. A.), elected a Fellow of the Society, 133.
——— Preliminary Report on the Tunicata of the Challenger Expedition: Part III. Cynthiadæ, 52; Part IV. Molgulidæ, 233.
Highland and Agricultural Society.—Report of their Committee on the Sheep Diseases known as Louping-ill and Braxy, 615.
Hoek (Dr. P. P. C.), Report on the Pycnogonida of the Faroe Channel, 689.
Holothurioidea of the Faroe Channel, by Dr. H. Theel, 694.
Home (D. Milne), LL.D., His Address on presenting the Makdougall-Brisbane Prize to Professor Piazzi Smyth, 362.
——— Remarks on presenting the 7th Boulder Report: Inquiry as to Whence and How Boulders have come to their present positions, 286, 293.

Home (D. Milne), LL.D., Remarks on presenting the Eighth Boulder Report, 778.
——— Objects for which the Boulder Committee was appointed, and lines of inquiry pursued, 778, 787.
Horne (John), elected a Fellow of the Society, 175.
Hydrocarbon Radicals, Haloid Compounds of, 46.
Hydrochlorate of Triethyl-phosphorus-betaine, 44.
Hypericaceæ Socotrenses, 502.

Ilmenites, 549.
Inglis (J. W.), elected a Fellow of the Society, 637.
Iodine Battery, by A. P. Laurie, 230.
Iron.—On the State of Carbon in Iron and Steel, by Dr. R. Sydney Marsden, 368.
——— The Dimensions of Cast-Iron at various Temperatures, with more especial reference to the Phenomena of the Solid floating on the Molten Metal, by W. J. Millar, 549.
Irrational Quantities, Equidistant Multiples of, by E. Sang, 2.
Iserines, 549.

Jaculella obtusa, 714.
Jamieson (Andrew), Recent Tests of Swan's Lamp for Fall of Resistance, 615.
——— elected a Fellow of the Society, 815.
Jamieson (Dr. Fife), Notes on the Bones in a Cist discovered at Parkhill, 405.
Jamieson (Thomas F.) on Boulders in Aberdeenshire and Perthshire, 282.
Jeffreys (Dr. Gwyn), F.R.S., Report on the Mollusca of the Faroe Channel, 680.
Jets (Liquid).—Effects of Rotation in Liquid Jets, 94.

Keith Prize (1879-81) presented to Professor Chrystal for his Paper on the Differential Telephone, 797.
Key (Thomas), F.R.S.E., Obituary Notice of, 95.
Kinetic Theory of Gases in relation to Dissociation, 806.
Kinetics, A Singular Problem in, 173.
Knox (Thomas), Obituary Notice of, 103.

Lago Maggiore, The Colour of its Waters, 477.
Lassell (Dr. William), Obituary Notice of, 97.
Laurence (Rev. William), Report as to Boulders in Fair Isle, 749.
Laurie (A. P.), B.Sc., on an Iodine Battery, 230.
——— Some Experiments on a New Secondary Cell, 724.
——— and C. J. Burton, on the Heats of Combination of the Metals with the Halogens, 804, 830.
Law XIV. amended.—The words *December to July* to be substituted for the words *November to June*, 421; and, when there are five Mondays in January, the Meetings shall be held on the third and fifth Mondays of that month, 567.
Lawson (Robert), M.B., elected a Fellow of the Society, 133.
Leaf-bed in Canna, 630.
Lecanoreæ Socotrenses, 460.
Lecideæ Socotrenses, 462.
Leguminosæ Socotrenses, 508.
Leslie (Alexander), Memb. Inst. C.E., elected a Fellow of the Society, 514.
Letts (Professor E. A.) on Phosphorus Betaines, 40.
——— On the Action of Haloid Compounds of Hydrocarbon Radicals on Phosphide of Sodium and on the Salts of Tetra-benzyl-phosphonium, 46.
Leucocytes.—Conclusions as to their Nature and Movements, 376.
Liddesdale, Carboniferous Rocks of, by Archibald Geikie, F.R.S., 600; Additional Fossil Fishes of, by Dr. R. H. Traquair, 603; Fossil Plants of, by R. Kidston, 603.
Light.—Nature of Vibrations in Common Light, by Professor Tait, 419.
Lindsay (Dr. William Lauder), Obituary Notice of, 736.
Livingston (Colin), Notes on Boulders and Striated Rocks at Fort-William, 765.
Livingston (Josiah), elected a Fellow of the Society, 622.
Liversidge (Professor A.) on Stilbite from Kerguelen's Island, 117.
Lochaber, *see* Mid-Lochaber, 483.
Loch Lomond: The Colour of its Waters, 479.
Longitude, Simple and Accurate Method of Determining, 117.
Longitude, Determination of, without a Chronometer, 293.
Lothian (Maurice), Obituary Notice of, 99.
Louping-ill: Report on, 615.

Loven (Professor Sven), elected a Foreign Honorary Fellow, 94.
Lowering of the Maximum Density Point of Water by Pressure, 626, 809.
Lyman (Professor Theodore), Report on the Ophiuroidea of the Faroe Channel, 707.
Lymnæus: Its Anatomy, by F. E. Beddard, B.A., 576.
Lyngbya scabrosa, 456.
Lythraceæ Socotrenses, 512.

Macfarlane (Dr. Alex.), Algebra of Relationship, Part II., 5.
——— Algebra of Relationship, Part III., 162; the Number of Genus Relationships of the 11th Order, 165; the Order-Index, 167; the Degree-Index, 165.
——— On Morgan's Systems of Consanguinity and Affinity, 245.
——— Electric Discharge through Colza Oil, 293.
——— and D. Rintoul, on the Effect of Flame on the Electric Discharge, 567.
——— and D. Rintoul, on the Effect of Moisture on the Electric Discharge, 801.
Macfarlane (J. M.), B.Sc., on the Vegetable Cell, 576.
Macintosh (Dr. W. C.), Note on a Phoronis dredged in H.M.S. "Challenger," 211.
M'Intosh (Professor W. Carmichael), Report on the Annelida of the Faroe Channel, 693.
——— Contributes an Obituary Notice of Dr. William Lauder Lindsay, 736.
Mackay (J. S.), M.A., elected a Fellow of the Society, 514.
Maclagan (David), F.R.S.E., contributes an Obituary Notice of David Smith, late Treasurer, 734.
——— (Professor) contributes Obituary Notice of Dr. Andrew Wood, 338.
M'Neill (Donald), Notes on the Boulders of Colonsay, 264.
Madeira.—On some Points in its Meteorology, by the Astronomer-Royal for Scotland, 629.
Mair (Rev. Hugh), Report as to Boulders at Keiss, 749.
Makdougall-Brisbane Prize for the period 1879-80, awarded to Professor Piazzi Smyth, Astronomer-Royal for Scotland, 361.
Malvaceæ Socotrenses, 503.
Manganese: Its Action on Steel, by Dr. R. S. Marsden, 566.
Marsden (Dr. R. Sydney) on the Crystallisation of Silica from Fused Metals, 37.
——— on the Manner in which Silicon, Phosphorus, Manganese, and other elements exert their influence upon Steel, 566.
——— on the Preparation of Adamantine Carbon or Diamond, 20.
——— on the State of Carbon in Iron and Steel; a New Hypothesis of the Hardening of Steel, 368.
Marshall (Professor D. H.) elected a Fellow of the Society, 622.
——— On the Lowering of the Maximum Density Point of Water by Pressure, 626, 809.
Marsipella cylindrica, 714.
Martite, 549.
Mazonia: A Genus of Scorpion, 245.
Meconates of Lead, 34; of Silver, 34.
Meconic Acid, not proved to be Tribasic, 33.
Mediterranean: Its Colour, by John Aitken, 472.
Menispermaceæ Socotrenses, 500.
Menzies (Dr.), Determination of Longitude without a Chronometer, 293.
Mesoplodon bidens (Sowerby's Whale), by Professor Turner, 443; Table of Cranial Measurements, 449; Spinal Column, 451; Dorsal Vertebræ, &c., 452-55.
Metals, Heats of Combination of, with the Halogens, 804, 830.
Microcosmus (Heller), a Genus of the Cynthiadæ described, 54.
——— *polymorphus* (Heller), 55.
——— *propinquus*, new species, 55.
Microphone.—On the Cause of Sounds produced in the Microphone Receiver, by Prof. James Blyth, 206.
——— Its Action, by Professor James Blyth, 622.
Microthamnion breviarticulatum, 456.
Mid-Lochaber: Its Surface Geology, by Professor Duns, 483.
Millar (W. J.) on the Dimensions of Cast Iron at various Temperatures, with more especial reference to the Phenomena of the Solid Floating on the Molten Metal, 549.
Milton (John), His "Defensio pro Populo Anglicano," in connection with the Dawn of the Constitutional Principle, 155.
Minding's Theorem, by G. Plarr, 528.
Mineralogy of Scotland, Chapter VII., by Professor Heddle, 549; Psilomelane, Turgite, and Martite, 549; Ilmenites and Iserines, 549.

Mirage, by Professor Tait, 354; Part II., 743; Part III., 798.
Moisture, its effect on the Electric Discharge, 801.
Molgulidæ, a family of the Tunicata, divided into four genera—Anurella, Molgula, Ctenicella, and Eugyra, 233.
Molgula, a Genus of the Tunicata.
——— *gigantea*, 234.
——— *gregaria*, 234.
——— *pedunculata*, new species, 234.
——— *horrida*, new species, 235.
——— *Forbesi*, new species, 236.
——— *pyriformis*, new species, 236.
Mollusca of the Faroe Channel, by Dr. Gwyn Jeffreys, F.R.S., 680.
Moncreiff (The Right Hon. Lord), President, His Introductory Address, 2, 136.
——— Receives the Thanks of the Society for his Address, 2.
——— Contributes an Obituary Notice of Lord Ormidale, 107.
Morgan's System of Consanguinity and Affinity, 245.
Morrison (William), Report as to Boulders in Ross-shire, 754.
Moscow.—The Imperial Society of Naturalists of Moscow invite the Royal Society to the Celebration of the Fiftieth Anniversary of the Graduation of Dr. Charles Renard, 567.
Muir (M. M. Pattison), M.A., on an Oxycyanide, and a New Oxide, of Bismuth, 557.
Muir (Thomas), M.A., on Professor Cayley's Theorem regarding a Bordered Skew Determinant, 187; the Law of Extensible Minors in Determinants, 187; Additional Note on a Problem of Arrangement, 187.
——— On a Class of Permanent Symmetric Functions, 409.
——— and Professor Chrystal on some Transformations connecting General Determinants with Continuants, 135.
Müller (Dr. J.), Diagnoses Lichenum Socotrensium Novorum, 457.
Murray (John) and Staff-Commander Tizard, Exploration of the Faroe Channel during the Summer of 1880 in the "Knight-Errant," 638.
——— Rocks of North Rona, Faroe, 720.
——— awarded the Neill Prize for 1877-80, 743; Prize presented, 797.
——— his Statement with respect to Applications for the Government Grant of £4000, 806.
Muscles of the Mammalian Foot, 162.
Neill Prize (1877-80) presented to Mr. John Murray for his Paper on the Structure and Origin of Coral Reefs and Islands, 797.
Nephropsis Atlantica, New Species of Crustacean, 684.
Newcomb (Professor Simon) elected a Foreign Honorary Fellow, 94.
——— Contributes an Obituary Notice of Professor Benjamin Peirce, 739.
Nicholson (Prof. H. Alleyne) on the Structure of the Skeleton of *Tubipora musica*, and on the Relation of the Genus Tubipora to Syringopora, 219.
Nicol (W. W. J.), the Action of Heat on Thioformanilid, 199.
——— Condition of Ammonium Salts when dissolved in Water, 819.
Norman (Rev. A. M.), Report on the Crustacea of the Faroe Channel, 683.
Numbers, Theory of, by Professor Tait, 245.

Obituary Notices of—
  Burton (Dr. John Hill), 324.
  Cumming (Dr. John), 328.
  Handyside (Dr. P. D.), 329.
  Key (Thomas), 95.
  Knox (Thomas), 103.
  Lassell (Dr. William), 97.
  Lindsay (Dr. William Lauder), 736.
  Lothian (Maurice), 99.
  Ormidale (The Honourable Lord), 107.
  Peirce (Professor Benjamin), 739.
  Ponton (Mungo), 100.
  Sanders (Professor), 333.
  Sharpey (Professor William), 110.
  Smith (David), Treasurer, 734.
  Wood (Dr. Andrew), 338.
Object-Glass.—Easy Method for Determining the Position of its Principal Focus, 50.
Office-Bearers for Session 1880-81, 1; for Session 1881-82, 324.
Omond (R. T.) on the Lowering of the Maximum Density Point of Water by Pressure, 626, 809.
Omphalarieæ Socotrenses, 457.
Ophiuroidea of the Faroe Channel, by Professor Theodore Lyman, 707.
Ormidale (Lord), Obituary Notice of, 107.
Oxidation of Ferrous Salts, by J. Y. Buchanan, 191.
Oxide (A New) of Bismuth, by M. M. Pattison Muir, M.A., 557.
Oxycyanide of Bismuth, by M. M. Pattison Muir, M.A., 557, 562.

Palæoniscidæ: Their Structure, by Dr. R. H. Traquair, 217.
Parmelieæ Socotrenses, 458.
Pasteur Medal, Invitation to subscribe for, 743.
Peach (B. Neeve) elected a Fellow of the Society, 175.
——— Some New Species of Fossil Scorpions, with a Review of the Genera Eoscorpius and Mazonia, 245.
——— Crustacea and Scorpions of the Carboniferous Rocks of the Scottish Border, 603.
Peddie (W.), Rotation of the Plane of Polarisation by Quartz, and its relation to wave-lengths, 816.
Pedicellariæ: Their Histology, by Patrick Geddes, F.R.S.E., and F. E. Beddard, B.A., 88.
Peirce (Professor Benjamin), Obituary Notice of, 739.
Peltier Effect due to Variation in Temperature, by Albert Campbell, 807.
Permanent Symmetric Functions, 409; Symmetric Functions distinguished from Alternating Functions; Determinants may be placed under the class of Alternating Functions, 409; Products of Permanents and Determinants of the n^{th} Order, 411.
Phoronis. — Note on a Phoronis Dredged in H.M.S. "Challenger," by Dr. W. C. Macintosh, 211.
Phosphate of Sodium, 46.
Phosphorus: Its Action on Steel, by Dr. R. S. Marsden, 566.
Phosphorus Betaines, by Prof. E. A. Letts, 40.
Physciæ Socotrenses, 459.
Pitchstone-Porphyry River of the Scuir of Eigg, 632.
Placodieæ Socotrenses, 459.
Placopoda Socot., 835.
Plane of Polarisation, Rotation of, by Quartz, 816.
Planispirina contraria, 713.
Planorbis: Its Anatomy, by F. E. Beddard, B.A., 576.
Plantamour (Professor Emile) elected a Foreign Honorary Fellow, 94.
Plarr (Dr. Gustav) on a Particular Case of the Symbolic Cubic, 342.
——— on Minding's Theorem, 528.
Platysomidæ: Their Structure, by Dr. R. H. Traquair, 217.
Pleurochæta Moseleyi, The Anatomy and Histology of, by F. E. Beddard, B.A., 629.
Polarisation (Galvanic), by Professor Helmholz, 202.
Polarisation, Rotation of the Plane of, 816.
Polycarpa, Heller, a Genus of the Cynthiadæ.
——— *irregularis*, new species, 72.
——— *longisiphonica*, new species, 77.
——— *minuta*, new species, 78.
——— *molguloides*, new species, 76.
——— *pedata*, new species, 71.
——— *pilella*, new species, 73.
——— *quadrata*, new species, 78.
——— *radicatus*, new species, 75.
——— *rigida*, new species, 76.
——— *sulcata*, new species, 73.
——— *tinctor* (Quoy and Guinard), 74.
——— *viridis*, new species, 74.
Polyzoa of the Faroe Channel, by Dr. G. Busk, 690.
Pompeii and Herculaneum—Historic Evidence of their Destruction: An Address by Rev. Dr. Cazenove, 421; Evidence of Martial, 425; Evidence of Plutarch, 426; Evidence of Statius, 427; Evidence of Tacitus, 430; Evidence of Josephus, 432; Evidence of Suetonius, 433; Evidence of the Younger Pliny, 433; Evidence of Dion Cassius, 437; Evidence of Marcus Aurelius, 441.
Ponton (Mungo), W.S., Obituary Notice of, 100.
Pressure.—Crushing of Glass by Pressure, by Professor Tait, 204.
——— on the Average Pressure due to Impulse of Vortex Rings on a Solid, by Sir William Thomson, 204.
——— on the Compression of Gases by High Pressures, 293.
Pressure-Errors of the "Challenger" Thermometers, by Prof. Tait, 199.
——— Note on the Heating produced by Compression, 217.
Prizes. — The Makdougall - Brisbane Prize for the Biennial Period 1879–81 awarded to Professor Piazzi Smyth, Astronomer-Royal for Scotland, 361.
——— Keith Prize for 1879–81 awarded to Professor Chrystal, 743.
——— Neill Prize for 1877–80 awarded to John Murray, 743.
Pryde (Dr. David) elected a Fellow of the Society, 637.
Pseudopodium: How produced, 31.
Psilomelane, 549.
Psoreæ Socotrenses, 460.
Pulvinulina scitula, 716.
Pycnogonida of the Faroe Channel, 689.
Pyrenuleæ Socotrenses, 471.

Quaternions. — On Quaternion Integration, by Professor Tait, 293.

Radiolarians and Cœlenterates: Their Yellow Cells, 377.
Ramalineæ Socotrenses, 458.
Rational Fractions, The Expansion of. 162.
Rattray (Dr. James Clerk) elected a Fellow of the Society, 421.
Refraction. — Professor Vince's Two Cases of Unusual Atmospheric Refraction, 581.
Relationship, The Algebra of, 162; Number of Genus Relationships of the n^{th} Order, 165.
Renard (Prof. A.) and John Murray, Rocks of North Rona, Faroe, 720.
Reophax difflugiformis, 715.
——— *adunca*, 715.
——— *sabulosa*, 715.
Resedaceæ Socotrenses, 501.
Resistance of Wires, 33.
Rhabdammina cornuta, 714.
Rhythm, by the Rev. J. L. Blake, 798.
Richardson (Ralph), F.R.S.E., Note on a Boulder at Loch Skene, 281.
——— Report as to Boulders at Strathnairn, 750.
Rintoul (D.) and Dr. A. Macfarlane on the Effect of Flame on the Electric Discharge, 567.
——— on the Effect of Moisture on the Electric Discharge, 801.
Robinson (The Rev. Dr. T. R.) contributes an Obituary Notice of Dr. William Lassell, 97.
Roccelleæ Socotrenses, 458.
Rocks, Order of Succession of, in the North-West Highlands, 815.
Rogerson (John Johnston), A.B., elected a Fellow of the Society, 233.
Rona (Faroe).—Rocks of North Rona, by Professor A. Renard and John Murray, 720.
Rosebery (The Right Hon. the Earl of) elected a Fellow of the Society, 233; admitted, 421.
Rotating Mass of Fluid, Figures of Equilibrium of, by Sir William Thomson, 610.
Rotation in Liquid Jets, by Professor Tait, 94.
Rotation of the Plane of Polarisation by Quartz, and its relation to Wave-Length, by W. Peddie, 816.
Rubiaceæ Socotrenses, 834.
Rumble (Thomas Wm.), Memb. Inst. C.E., elected a Fellow of the Society, 133.
Rutaceæ Socotrenses, 505.
Rutherford (Samuel), His Treatise "Lex Rex" in connection with the Dawn of the Constitutional Principle, by Lord Moncreiff, 151.

Salmasius (Joannes), His "Defensio Regia pro Carolo Primo," in connection with the Dawn of the Constitutional Principle, by Lord Moncreiff, 153.
Salmon (Rev. Professor George) elected a British Honorary Fellow, 95.
Sanders (Professor W. R.), Obituary Notice of, 333.
Sanderson (James, Dep. Inspector-Gen. of Hospitals) contributes an Obituary Notice of Thomas Key, 95.
Sang (Edward), on Equidifferent Multiples of Irrational Quantities, 2.
——— on the Solar Eclipse of 31st December 1880, 18.
——— Notice of the Solar Eclipse of the 17th May 1882, with Remarks on the Calculation, 720.
——— Notice of an Easy Method for Determining the Position of the Principal Focus of an Object Glass, 50.
——— Moves an Addition to Law XIV. "That when there are five Mondays in January, meetings shall be held on the 3rd and 5th Mondays of that month," 421; His Motion Adopted, and Law XIV. Amended accordingly, 567.
——— A Critical Examination of Two Cases of Unusual Atmospheric Refraction, described by Professor Vince, 581.
Sapindaceæ Socotrenses, 507.
Schultze (Dr. F. E.) on the Structure of Euplectella, 2.
Schweinfurth (Dr.), *Lichenes Socotrenses*, 457.
Scorpions, New Fossil, by B. N. Peach, 245.
Scott (Alexander), Fungi et Algæ in Insula Socotra, 456.
Sea Water: Its Absorption, by John Aitken, 637.
——— Gas Contents of Water of Faroe Channel, by Prof. Dittmar, 718.
Secondary Cell.—Some Experiments on a New Secondary Cell, by A. P. Lawrie, B.Sc., 724.
Selenium Cell, A Simple Form of, by Professor James Blyth, 119.
Serpentine: Its Formation from Dolomite, by Dr. J. J. Dobbie, and G. G. Henderson, B.Sc., 606.

Shand (The Hon. Lord) contributes an Obituary Notice of Thomas Knox, 103.
Sharpey (Prof. William), Obituary Notice of, 110.
Sheep Diseases, known as Louping-ill and Braxy, 615.
Silica : Its Crystallization from Fused Metals, by Dr. R. Sydney Marsden, 37.
Silicon : Its Action on Steel, by Dr. R. S. Marsden, 566.
Sladen (W. P.), F.L.S., Report on the Asteroidea of the Faroe Channel, 698.
Smith (Professor C. Michie) elected a Fellow of the Society, 622.
—— Notes on Atmospheric Electricity, 613.
—— On the Lowering of the Maximum Density Point of Water by Pressure, 626, 809.
Smith (David), late Treasurer, Obituary Notice of, 734.
Smyth (Professor Piazzi), Astronomer-Royal for Scotland, awarded the Makdougall-Brisbane Prize for the Period 1879–80, 361.
—— on some Points in the Meteorology of Madeira, 629.
Snails (Pond), Their Nervous System, by F. E. Beddard, B.A., 576.
Socotra, Island of, by Professor I. Bayley Balfour, 245.
—— Diagnoses Plantarum Novarum et Imperfecte descriptarum Socotrensium, 456, 498, 834.
Solar Calorimeter, and some Observations made with it in Upper Egypt, 827.
Solar Eclipse of 31st December 1880, by Edward Sang, 18.
Solar Eclipse of 18th May 1882, by Edward Sang, 720.
Solution—its Nature, by W. L. Goodwin, 834.
Sonometer (Electric), by Prof. James Blyth, 28.
Sorley (James) elected a Fellow of the Society, 598.
Sowerby's Whale (*Mesoplodon bidens*), by Professor Turner, 443.
Space-Loci, by Professor Tait, 187.
Sprague (T. B.), Mathematical Note, title only, 000.
Statistics : Their Classification, by Patrick Geddes, F.R.S.E., 295.
Steam shows Impure and Dusty State of Atmosphere, 15.
Steel.—On the State of Carbon in Iron and Steel, by Dr. R. Sydney Marsden, 368.
Steel.—On the Influence of Silicon, Phosphorus, and Manganese on, by Dr. R. S. Marsden, 566.
Steenstrup (Professor Johannes Iapetus Smith) elected a Foreign Honorary Fellow, 95.
Sterculiaceæ Socotrenses, 503.
Sterium retirugum, a New Fungus, 456.
Stevenson (Charles Alexander), B.Sc., The Earthquake of 28th November 1880 in Scotland and Ireland, 176.
Stilbite from Kerguelen's Island, by Professor A. Liversidge, 117.
Storm : Its Motion in an Easterly Direction only possible as a Circular Atmospheric Wave, by Robert Tennent, 209.
Styela bythia, new species, 63.
—— *clava*, new species, 70.
—— *convexa*, new species, 69.
—— *exigua*, new species, 68.
—— *flava*, new species, 64.
—— *glans*, new species, 65.
—— *grandis*, new species, 67.
—— *gyrosa*, Heller, 67.
—— *lactea*, new species, 68.
—— *Macleay*, a genus of the Cynthiadæ, 62.
—— *oblonga*, new species, 65.
—— *squamosa*, new species, 66.
Styelinæ, a Sub-family of the Cynthiadæ, 53.
Sulphate of Triethyl-phosphorus-betaine, 45.
Sulphur, when burned, a Fog-producer, 18.
Surface Tension.—Method of showing Diminution of Surface Tension in Water by Heat, by Professor Tait, 131.
Sutherland Marble, A supposed Organism from, by Professor Heddle, 634.
Swan's Lamp, Recent Tests of, by A. Jamieson, 615.
Sydney (Algernon), His "Treatise on Government," in connection with the Dawn of the Constitutional Principle, by Lord Moncreiff, 160.
Symbolic Cubic, A Particular Case of, by Dr. Gustav Plarr, 342.
Symmetric Functions.—On a Class of Permanent Symmetric Functions, by Thomas Muir, 409.
Syringopora.—The Structure and Relation of the Genus Tubipora to Syringopora, by Dr. H. Alleyne Nicholson, 219.

Tait (Professor P. G.), Note on the Temperature Changes due to Compression, 51, 217.
——— on some Effects of Rotation in Liquid Jets, 94.
——— Note on the Influence of Temperature-Change of Conductivity on the Conduction of Heat in Solids, 94.
——— Note on Thermal Conductivity, and on the Effects of Temperature-Changes of Specific Heat and Conductivity on the Propagation of Plane Heat Waves, 126.
——— Simple Method of Showing the Diminution of Surface Tension in Water by Heat, 131.
——— Note on a Singular Problem in Kinetics, 173.
——— on some Space-Loci, 197.
——— on the Pressure-Errors of the "Challenger" Thermometers, 199.
——— on the Crushing of Glass by Pressure, 204.
——— Note on a Proposition in the Theory of Numbers, 245.
——— on the Compression of Gases by High Pressures, 293.
——— on Quaternion Integration, 293.
——— on Mirage (Abstract), 354; Part II., 743; Part III., 798.
——— Optical Notes (1) on a Singular Phenomenon produced by some Old Window-Panes, 418; (2) On the Nature of the Vibrations in Common Light, 419.
——— His Address on Presenting the Keith Prize to Professor Chrystal, 797.
——— Kinetic Theory of Gases in relation to Dissociation, 806.
——— Note on the Lowering of the Maximum Density Point of Water by Pressure, 813.
Tennent (Robert) on the Motion of a Storm in an Easterly Direction being only possible as a Circular Atmospheric Wave, 209.
Tetra-Benzyl-Phosphonium, 46; Chloride of, 47; Acid Sulphate of, 48; Hydrate of, 49.
Textularia aspera, 715.
Trametes Socotrana, a New Fungus, 456.
Theel (Dr. Hjalmar), Report on the Holothurioidea of the Faroe Channel, 694.
Thermal Conductivity, by Professor Tait, 126.
Thermo-Dynamic Acceleration of the Earth's Rotation, by Sir William Thomson, 396.
Thermometers.—Pressure-Errors of the "Challenger" Thermometers, by Professor Tait, 199.
Thioformanilid, The Action of Heat on, by W. W. J. Nicol, 199.
Thomson (Dr. Allen) contributes an Obituary Notice of Dr. William Sharpey, 110.
——— (William), M.A., B.Sc., elected a Fellow of the Society, 598.
——— (Sir William), Hon. Vice-President, Effect of Moistening with Water the opposed Metallic Surfaces in a Volta-Condenser, and of substituting a Water Arc for a Metallic Arc in the Determining Contact, 135.
——— on Vortex Sponge, 135.
——— on the Average Pressure due to Impulse of Vortex-Rings on a Solid, 204.
——— on the Thermo-Dynamic Acceleration of the Earth's Rotation, 396.
——— on the Figures of Equilibrium of a Rotating Mass of Fluid, 610.
Tiliaceæ Socotrenses, 504.
Tizard (Staff-Commander) and John Murray, Exploration of the Faroe Channel, during the Summer of 1880, in the "Knight Errant," 638.
Todd (D. P.), Letter as to his Search for a Trans-Neptunian Planet, 91.
Traill (William), Report as to Boulders in North Ronaldshay, 746.
Traquair (Dr. R. H.), Additional Researches on the Structure of the Palæoniscidæ and Platysomidæ, 217.
——— Additional Fossil Fishes of Eskdale and Liddesdale, 603.
Triethyl-phosphine, 41.
——— phosphorus-betaine, Ethyl-chlorate of, 42; Ethyl-bromate and Ethyl-iodate of, 43; Action of Heat on Compounds of, 43; Hydrochlorate of, 43; Sulphate of, 45.
——— methyl-phosphonium, 45.
Tubipora musica: The Structure of its Skeleton, and the Relation of the genus Tubipora to Syringopora, by Dr. H. Alleyne Nicholson, 219.
Tunicata of the "Challenger" Expedition, by Dr. W. A. Herdman. Part III. Cynthiadæ, 52; Part IV. Molgulidæ, 233.
Turgite, 549.
Turner (Professor) on a Specimen of Sowerby's Whale (*Mesoplodon bidens*), captured in Shetland, 443.
——— on a Specimen of *Balænoptera borealis* or *laticeps*, captured in the Firth of Forth, 515.

Ultra-Neptunian Planet, by Professor George Forbes, 89.

Umbelliferæ Socotrenses, 513.

Valerianaceæ Socotrenses, 837.

Vapour always Condenses in the Atmosphere on a Solid Nucleus, 15.

Verrucarieæ Socotrenses, 471.

Vertigo, A Case of, by Professor Crum Brown, 594.

Vibrations in Common Light, by Professor Tait, 419.

Vince (Professor), His Two Cases of Unusual Atmospheric Refraction, by Edward Sang, 581.

Vocalisation and Articulation, by the Rev. J. L. Blake, 815.

Voice-Effort and Rhythm, by the Rev. J. L. Blake, 798.

Vortex-Rings.—On the Average Pressure due to Impulse of Vortex-Rings on a Solid, by Sir William Thomson, 204.

Vortex-Sponge, by Sir William Thomson, 135.

Wallace.—Report as to Boulders near Inverness, 751.

Water, Colour of, by John Aitken, 472.

——— the Lowering of its Maximum Density-Point by Pressure, by Professor D. H. Marshall, C. M. Smith, and R. T. Omond, 626, 809.

Wenley (J. A.), elected a Fellow of the Society, 815.

Whitehead (Walter) elected a Fellow of the Society, 133.

Wires.—Effect of Elongation on Resistance of Wires, by T. Gray, 33.

Wise (Dr. T. A.) re-elected a Fellow of the Society, 14.

Witch's Stone Boulder, 266.

Witkowski (M. August), Effects of Strain on Electric Conductivity, 135.

Wood (Dr. Andrew), F.R.S.E., Obituary Notice of, 338.

Wyville Thomson Ridge in the Faroe Channel, 648.

Young (Andrew) elected a Fellow of the Society, 361.

Young (F. W.) elected a Fellow of the Society, 637.

Young (Thomas Graham) elected a Fellow of the Society 598.

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PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

SESSION 1880–81.

CONTENTS.

PAGE

General Statutory Meeting, Monday, 22d November 1880.

Election of Office-Bearers, ... 1

Monday, 6th December 1880.

Introductory Address by the President, the Right Hon. Lord Moncreiff, ... 2
On the Structure of *Euplectella*. By Dr F. E. Schültze. Communicated by Sir Wyville Thomson, . . 2
On Equidifferent Multiples of Irrational Quantities. By Mr E. Sang, ... 2
Algebra of Relationship. Part II. By A. Macfarlane, M.A., D.Sc., F.R.S.E., ... 5

Monday, 20th December 1880.

On Dust, Fogs, and Clouds. By Mr John Aitken, . 14
Solar Eclipse, 31st December 1880. By Mr E. Sang, . 18
On the Preparation of Adamantine Carbon or Diamond. By R. Sydney Marsden, D.Sc., F.R.S.E., F. Inst. Chem., &c., 20
Note on an Electric Sonometer. By Prof. James Blyth, . 28
Theory to account for certain movements exhibited by low forms of Animal Life, and termed Amœboid. By John B. Haycraft, Senior Demonstrator of Physiology in the University of Edinburgh, ... 29

Monday, 3d January 1880.

On the Effect of Permanent Elongation on the Specific Resistance of Wires. By Mr T. Gray. Communicated by Sir William Thomson, ... 31
Meconic Acid. By Mr D. B. Dott. Communicated by Professor Crum Brown, ... 31
On the Crystallization of Silica from Fused Metals. By R. Sydney Marsden, D.Sc., F.R.S.E., F. Inst. Chem., &c., 34
On Phosphorus Betaines. By Professor E. A. Letts, . 37
On the Action of Haloid Compounds of Hydrocarbon Radicals on Phosphide of Sodium and on the Salts of Tetra-Benzyl-Phosphonium. By Professor Letts and N. Collie, Esq., ... 46
Notice of an Easy Method for determining the Position of the Principal Focus of an Object-Glass. By Mr Edward Sang, 50
Note on the Temperature Changes due to Compression. By Professor Tait, ... 51

Monday, 17th January 1881.

PAGE

Preliminary Report on the *Tunicata* of the "Challenger" Expedition. Part III. By W. A. Herdman, D.Sc., . 52
On the Histology of the Pedicellariæ and the Muscles in *Echinus sphæra*, Forbes. By Mr Patrick Geddes, F.R.S.E., Lecturer on Zoology in the School of Medicine, Edinburgh, and Mr Frank E. Beddard, B.A., Assistant-Demonstrator of Zoology, Oxford, . . 88
Additional Note on an Ultra-Neptunian Planet. By Professor George Forbes, ... 89
On some Effects of Rotation in Liquid Jets. By Professor Tait, ... 94
Note on the Influence of Temperature-Change of Conductivity on the Conduction of Heat in Solids. By Professor Tait, ... 94

Monday, 7th February 1881.

Obituary Notices of Fellows who died in the course of Session 1880–81:—Mr Thomas Key, Dr William Lassell, Mr Maurice Lothian, Mr Mungo Ponton, Mr Thomas Knox, the Hon. Lord Ormidale, Professor Sharpey, ... 95–116
On a Simple and Accurate Method of determining the Longitude of a Place by a Single Observer, without the aid of any instrument for measuring time. By Professor George Forbes, ... 117
Stilbite, from Kerguelen's Island. By A. Liversidge, Assoc. Royal School of Mines, Professor of Geology and Mineralogy, University of Sydney. Communicated by Mr J. Y. Buchanan, ... 117
On a Simple Form of Selenium Cell, and Experiments therewith. By Professor James Blyth, ... 119
Dust, Fogs, and Clouds. By Mr John Aitken, . . 122
Note on Thermal Conductivity, and on the Effects of Temperature-Changes of Specific Heat and Conductivity on the Propagation of Plane Heat Waves. By Professor Tait, ... 126
Note on a Simple Method of showing the Diminution of Surface Tension in Water by Heat. By Professor Tait, . 131
On the Cell-Walls of Hepatic Cells. By John Berry Haycraft, M.B., B.Sc., F.R.S.E., Senior Demonstrator of Physiology in the University of Edinburgh, . . 131

Monday, 21st February 1881.

Effects of Strain on Electric Conductivity. By M. August Witkowski. Communicated by Sir William Thomson, 135
On the Effect of Moistening with Water the opposed Metallic Surfaces in a Volta-Condenser, and of substituting a Water-Arc for a Metallic-Arc in the Determining Contact. By Sir William Thomson, ... 135
On Vortex Sponge. By the Same, ... 135

For continuation of Contents, see pp. 3 and 4 of Cover.

PAGE
On some Transformations connecting General Determinants with Continuants. By Mr **Thomas Muir**, . . 135
Note on the preceding Paper. By Professor **Chrystal**, . 135

Monday, 7th March 1881.

Introductory Address by the President, the Right Hon. **Lord Moncreiff**. (Continued from p. 2), . . 136
On the Intrinsic Muscles of the Mammalian Foot. By Dr D. J. **Cunningham**, ... 162
On the Expansion of Rational Fractions, &c. By Mr A. H. **Anglin**, ... 162
Algebra of Relationship. Part III. By A. **Macfarlane**, M.A., D.Sc., F.R.S.E., ... 162
Note on a Singular Problem in Kinetics. By Professor **Tait**, ... 173

Monday, 21st March 1881.

The Earthquake of 28th November 1880 in Scotland and Ireland. By **Charles Alexander Stevenson**, B.Sc. Edin. Communicated by Professor **Geikie** (Plate I*a*), 176
On the Classification of Statistics. Part I. By Mr P. **Geddes**, 187
On Professor Cayley's Theorem regarding a Bordered Skew Determinant. By Mr **Thomas Muir**, M.A., . . 187
The Law of Extensible Minors in Determinants. By Mr **Thomas Muir**, M.A., ... 187
Additional Note on a Problem of Arrangement. By Mr **Thomas Muir**, M.A., ... 187
On the Oxidation of Ferrous Salts. By Mr J. Y. **Buchanan**, 191
On some Space-Loci. By Professor **Tait**, . . . 197

Monday, 4th April 1881.

On the Pressure-Errors of the "Challenger" Thermometers. By Professor **Tait**, ... 199
The Action of Heat on Thioformanilid. By W. W. J. **Nicol**, M.A., ... 199
On the Classification of Statistics. Part II. By Mr P. **Geddes**, ... 202

Monday, 18th April 1881.

On Galvanic Polarisation. By Professor **Helmholtz**, . 202
On the Average Pressure due to Impulse of Vortex Rings on a Solid. By Sir **William Thomson**, . . . 204
On the Crushing of Glass by Pressure. By Professor **Tait**, 204
On the Cause of the Sounds produced in the Microphone Receiver. By Professor **James Blyth**, . . 206

Monday, 2d May 1881.

On the Classification of Statistics. Part III. Results. By Mr **Geddes**, ... 209
On the Motion of a Storm in an Easterly Direction being only possible as a Circular Atmospheric Wave. By **Robert Tennent**, ... 209
On Chemical Nomenclature and Notation. By Professor **Crum Brown**, ... 211

Monday, 16*th May* 1881.

PAGE
Note on a *Phoronis* dredged in H.M.S. "Challenger." By W. C. M'Intosh, ... 211
Additional Researches on the Structure of the *Palæoniscidæ* and *Platysomidæ*. By Dr R. H. Traquair, . . 217
Note on the Heating produced by Compression. By Professor Tait, ... 217

Monday, 6*th June* 1881.

On the Structure of the Skeleton of *Tubipora musica*, and on the Relation of the Genus *Tubipora* to *Syringopora*. By Professor H. Alleyne Nicholson, M.D., D.Sc., . 219
On an Iodine Battery. By Mr A. P. Laurie. Communicated by Professor Tait, ... 230
Note on Chemical Affinity and Atomicity. By William Durham, ... 231
On the Physical and Biological Conditions of the Channel between Scotland and the Farö Islands. By Sir C. Wyville Thomson, ... 233

Monday, 20*th June* 1881.

On a Class of Sturmian Functions. By Professor Chrystal, 233
Preliminary Report on the *Tunicata* of the "Challenger" Expedition. Part IV. By W. A. Herdman, D.Sc., . 233
On Comenic Acid. By D. B. Dott. Communicated by Professor Crum Brown, ... 241
On Morgan's Systems of Consanguinity and Affinity. By Dr Macfarlane, ... 245
Note on a Proposition in the Theory of Numbers. By Professor Tait, ... 245

Monday, 4*th July* 1881.

An Address on the Island of Socotra. By Professor I. Bayley Balfour, ... 245
On some new species of Fossil Scorpions from the Carboniferous Rocks of Scotland and the English Borders, with a Review of the genera *Eoscorpius* and *Mazonia* of Messrs Meek and Worthen. By B. N. Peach, . 245

Monday, 18*th July* 1881.

Report of the Boulder Committee, with Remarks by the Convener, Mr D. Milne Home. (Plates I., II., III.), . 246
On the Compression of Gases by High Pressures. By Professor Tait, ... 293
Determination of Longitude without a Chronometer. By Dr Menzies. Communicated by Professor Tait, . 293
Electric Discharge through Colza Oil. By A. Macfarlane, M.A., D.Sc., F.R.S.E., ... 293
On Quaternion Integration. By Professor Tait, . . 293
Chairman's Concluding Remarks at the close of the Session, 293
On the Classification of Statistics and its Results. By Patrick Geddes, F.R.S.E., ... 295

PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

SESSION 1881–82.

CONTENTS.

PAGE

General Statutory Meeting, Monday, 28th November 1881.

Election of Office-Bearers, ... 323

Monday, 5th December 1881.

Obituary Notices of Dr. John Hill Burton, Rev. Dr. Cumming, Dr. P. D. Handyside, Professor Sanders, Dr. Andrew Wood, 324
On a Particular Case of the Symbolic Cubic. By Dr. Gustav Plarr. Communicated by Professor Tait, . . 342
On Mirage. By Professor Tait, ... 354

Monday, 19th December 1881.

Macdougall-Brisbane Prize, ... 361
On the Application of the Rocks of Ben Nevis to Ornamental Art. By Sir R. Christison, Bart., *Hon. V.P.*, . . . 365
On the State of Carbon in Iron and Steel: a New Hypothesis of the Hardening of Steel. By R. Sydney Marsden, D.Sc., F.R.S.E., &c., ... 368
Some Physical Experiments bearing upon the Circulation of the Blood-Corpuscles. By D. J. Hamilton, M.B., F.R.C.S.E., F.R.S.E., ... 370

Monday, 16th January 1882.

On the Nature and Functions of the "Yellow Cells" of Radiolarians and Cœlenterates. By Patrick Geddes, . . 377
On the Thermodynamic Acceleration of the Earth's Rotation. By Sir William Thomson, ... 396
Notes on a Cist discovered at Parkhill, Dyce, Aberdeenshire, in October 1881. By William Ferguson of Kinmundy. With Notes on the Bones by Dr. Fife Jamieson, M.B., . . 405
On a Class of Permanent Symmetric Functions. By Thomas Muir, M.A., ... 409
Optical Notes. By Professor Tait, ... 418

Monday, 30th January 1882.

The Historic Evidence for the Destruction of Pompeii and Herculaneum. By the Rev. Dr. Cazenove, . . . 421
On a Specimen of Sowerby's Whale (*Mesoplodon bidens*) captured in Shetland. By Professor Turner, . . . 443
On Respiration in the Roots of *Avicennia officinalis* (Linn.) and other Shore Plants; with Observations on the Functions of the Lenticels. By Joseph Bancroft, M.D. Communicated by Professor Balfour, *V.P.*, ... 456

PAGE
(*a*) Diagnoses Fungorum novorum in Insula Socotra a Bayley Balfour, Carolo Cockburn et Alexandro Scott, lectorum, quas elaboravit Dr. M. C. Cooke. Communicated by Dr. Bayley Balfour, ... 456
(*b*) Diagnoses Algarum novarum Socotrensium a Bayley Balfour, Carolo Cockburn et Alexandro Scott, lectorum, quas elaboravit Dr. G. Dickie, F.R.S., ... 456
(*c*) Diagnoses Lichenum Socotrensium novorum a participibus expeditionum Prof. Bayley Balfour et Dr. Schweinfurth, lectorum, quas elaboravit Dr. J. Müller. Communicated by Dr. Bayley Balfour, ... 457

Monday, 6*th February* 1882.

On the Colour of the Mediterranean and other Waters. By Mr. John Aitken, ... 472
The Surface Geology of Mid-Lochaber. By Professor Duns, D.D., 483
Remarks on Dielectric Strength. By Professor Chrystal, . 487
Diagnoses Plantarum novarum et imperfecte descriptarum Phanerogamarum Socotrensium; quas elaboravit Bayley Balfour, Scientiæ Doctor et in Universitate Glascuensi rerum botanicarum regius professor. Pars Prima, ... 498

Monday, 20*th February* 1882.

On a Specimen of *Balænoptera borealis* or *laticeps* captured in the Firth of Forth. By Professor Turner, ... 515
On Minding's Theorem. By M. G. Plarr. Communicated by Professor Tait, ... 528
Chapters on the Mineralogy of Scotland. Chapter VII. By Dr. Heddle, ... 549
On the Dimensions of Cast Iron at various Temperatures, with more especial reference to the Phenomena of the Solid floating on the Molten Metal. By W. J. Millar, C.E., Secretary Inst. Engineers and Shipbuilders in Scotland, . . 549
On an Oxycyanide, and a New Oxide of Bismuth. By M. M. Pattison Muir, M.A., Fellow, and Prælector in Chemistry, of Gonville and Caius College, Cambridge, ... 557
Mathematical Note. By Mr. T. B. Sprague, ... 566
On the Manner in which Silicon, Phosphorus, Manganese, and other elements exert their influence upon Steel. By R. Sydney Marsden, D.Sc., F.R.S.E., F.C.S., &c., . . 566

Monday, 6*th March* 1882.

The Effect of Flame on the Electric Discharge. By Dr. A. Macfarlane and Mr. D. Rintoul. (Plate IV. *a*), . . 567
Observations on Vegetable and Animal Cells; their Structure, Division, and History. Part I., The Vegetable Cell. By J. M. Macfarlane, B.Sc. Communicated by Professor A. Dickson, ... 576
On some Points in the Anatomy of the Nervous System of the Pond Snails, Planorbis and Lymnæus. By F. E. Beddard, B.A., New College, Oxon. Communicated by Mr. P. Geddes, 576
A Critical Examination of two Cases of unusual Atmospheric Refraction described by Professor Vince. By Mr. Edward Sang, ... 581

For continuation of Contents, see pp. 3 and 4 of Cover.

PAGE
On a Case of Dyspeptic Vertigo. By Professor Crum Brown, . 594

Monday, 20th March 1882.

Note on the Carboniferous Rocks of the South of Scotland. By Archibald Geikie, F.R.S., ... 598
Additional Contributions to our Knowledge of the Fossil Fishes of Eskdale and Liddesdale. By Dr. R. H. Traquair, . . 603
Further Researches among the Crustacea and Scorpions of the Carboniferous Rocks of the Scottish Border. By Mr. B. N. Peach, ... 603
Report on the Fossil Plants collected by the Geological Survey of Scotland in Eskdale and Liddesdale. By Robert Kidston, F.R.P.S., ... 603
On the Formation of Serpentine from Dolomite. By J. J. Dobbie, M.A., D.Sc., Assistant to the Professor of Chemistry, University of Glasgow, and G. G. Henderson, B.Sc., . . 606

Monday, 3d April 1882.

On a Rotating Mass of Fluid. By Sir William Thomson, . 610
Notes on Atmospheric Electricity. By Prof. C. Michie Smith, . 613
Recent Test of Swan's Lamp for fall of Resistance, with increase of Electromotive Force, and Ratio of Candle-power to work expended. By Mr. A. Jamieson. Communicated by Professor Chrystal, ... 615
Communication of Preliminary Observations made by the Committee appointed by the Highland and Agricultural Society to investigate the Nature and Causes of the Sheep Diseases known as Louping-ill and Braxy, ... 615

Monday, 17th April 1882.

On the Definite Article in Greek, with special reference to the Revised Version of the New Testament. By Prof. Blackie, . 622
On the Action of the Microphone. By Prof. James Blyth, M.A., 622
Experiments to Determine the Lowering of the Maximum Density Point of Water by Pressure. By Professor D. H. Marshall, Professor C. Michie Smith, and Mr. R. T. Omond, . . 626

Monday, 1st May 1882.

On some Points in the Meteorology of Maderia, both Absolute and Comparative. By the Astronomer-Royal for Scotland, . 629
On the Anatomy and Histology of *Pleurochæta Moseleyi*. By F. E. Beddard, B.A., New College, Oxford, ... 629
Geological Notes. By Professor Heddle, ... 630
Note on the Absorption of Sea Water. By Mr. John Aitken, . 637

Monday, 15th May 1882.

Exploration of the Faroe Channel, during the Summer of 1880, in H.M.'s hired ship "Knight Errant." By Staff-Commander Tizard, R.N., and Mr John Murray; with Subsidiary Reports. (Plate VI.), ... 638
Notice of the Solar Eclipse of the 17th May, with Remarks on the Calculation. By Mr. Edward Sang, ... 720
Some Experiments on a New Secondary Cell. By Mr. A. P. Laurie, B.Sc., ... 724

PAGE

Monday, 5th June 1882.

Obituary Notices of Mr. David Smith, Dr. William Lauder Lindsay, and Professor Benjamin Peirce, . . . 734
On Mirage. Part II. By Professor Tait, . . . 743
Report of the Boulder Committee, with Remarks by the Convener, Mr. Milne Home. (Plates IV., V.), . . . 743
Supplement to the Eighth Report of the Boulder Committee, . 787

Monday, 19th June 1882.

On Mirage. Part III. By Professor Tait, . . . 799
On a Red Resin from *Dracæna Cinnabari* (Balf. fil.) Socotra. By Messrs. J. J. Dobbie, Assistant to the Professor of Chemistry, University of Glasgow; and G. G. Henderson, B.Sc. Communicated by Dr. Bayley Balfour, . . . 799
On Voice-Effort and Rhythm. By the Rev. J. L. Blake. Communicated by Professor Crum Brown, . . . 799
The Effect of Moisture on the Electric Discharge. By A. Macfarlane, M.A., D.Sc., and D. Rintoul, M.A., . . 801
The Heats of Combination of the Metals with the Halogens. By Messrs. A. P. Laurie and C. I. Burton. Communicated by Professor Crum Brown, ... 804

Monday, 3rd July 1882.

On the Kinetic Theory of Gases in relation to Dissociation. By Professor Tait, ... 806
On the Change in the Peltier Effect due to Variation in Temperature. By Mr. Albert Campbell. Communicated by Dr. Knott, . 807
On the Lowering of the Maximum Density Point of Water by Pressure. By Professor D. H. Marshall, Professor C. Michie Smith, and Mr. R. T. Omond, . . . 809
Note on the Preceding Paper. By Professor Tait, . . 813
Vocalisation and Articulation. By the Rev. J. L. Blake. Communicated by Dr. Crum Brown, ... 815

Monday, 17th July 1882.

On the Order of Succession of Rocks in the North-West Highlands. By Professor Heddle, ... 815
On the Rotation of the Plane of Polarization by Quartz, and its relation to Wave-Length. By Mr. W. J. Peddie. Communicated by Professor Tait, ... 815
On the Condition of Ammonium Salts when dissolved in Water. By W. W. J. Nicol, M.A., B.Sc. Part I., . . . 819
On a Solar Calorimeter, and some Observations made with it in Upper Egypt. By Mr. J. Y. Buchanan, ... 827
On the Heats of Combination of the Metals with the Halogens. By Messrs. A. P. Laurie, B.Sc., and C. I. Burton, . . 830
On the Nature of Solution. By Mr. W. L. Goodwin. Communicated by Professor Crum Brown, ... 834
Diagnoses plantarum novarum et imperfecte descriptarum Phanerogamarum Socotrensium, quas elaboravit Bayley Balfour, Scientiæ Doctor et in Universitate Glascuensi rerum botanicarum regius professor. Pars altera, ... 834
Review of the Session, ... 843
Donations to the Library, ... 845
Index, ... 871